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From Painting by Fritz Werner.

## THE LATE PRINCE BISMARCK.

BORN, 1815. DIED, 1898.

## PRINCE BISMARCK'S CAREER.

BISMARCK humbled Austria and made the North German Union. He conquered France and founded the German Empire. His shadow lay over the States and statesmen of the Continent for full thirty years. In it reputations withered and powers waned, small men grew great, and nations were created. The Hapsburgers were thrust aside and the Bonapartes were dethroned. The laurels of the Metternichs and the Schwarzenbergs died away and the Gagerns, Manteuffels, and Camphausens were forgotten. Mere association with him, mere opposition to him, was fame, and the names of Crispi, Gortschakoff, Kalnoky, Andrassy, and Giers were known to all the world. His heavy hand was felt in every cabinet and court. His life became the history of modern Europe.

The most orthodox biographers of Bismarck have been unable to find in his early years the promise of his greatness. He was a daredevil, but otherwise was as most other young Germans are. When Bismarck entered Göttingen in the spring of 1832, his principal idea seems to have been that he must do credit to such an ancestry, and he did it. He was then a lank, bony, ungraceful boy, with a long reach and an enormous stride. Plenty of riding and hunting on his father's estate at Schoenhausen had given him hard muscles and a sound body. The grinding routine of his preparatory education at a gymnasium had whetted his desire for the full freedom of university life.

In July of 1847 he married Johanna von Puttkamer. Immediately after his marriage he first became conspicuous as the most reactionary member of the new Prussian Parliament. It was not much of a parliament, but the best withal that could be squeezed out of Frederick William IV., who was too full of plans for his college of kings and loving fellowship with Austria to do much for his people. Bismarck despised the parliament, hated the revolution, and swore oaths to the infallibility of all royal policies. He even went so far as to defend the agreement of Olmuetz, by which Prussia, at Austria's dictation, was forced to eat her own words, abjure her legitimate policy, and sink humbly below Austria in the confederation of German States, whose work was done by her army and whose benefits were monopolized by the intriguers in Vienna. Although then, as ever, Prussian to the heart's core, Bismarck undoubtedly was still in the wake of the Berlin statesman who wished friendship with Austria at any price, and felt it to be God-ordained that the Metternichs and Schwarzenbergs of the Hapsburg dynasty should reap the finest fruits of European diplomacy.

His eyes were opened at the Diet in Frankfort, to which he was sent in 1851. His special mission was to seal a friendly alliance between Austria and Prussia. No man ever had keener eyes for piercing shams than had Bismarck. A few weeks in Frankfort destroyed his illusions completely. He found the Diet a "consequential knot of bestarred and beribboned gentlemen." Count Thun, who presided in the name of Austria, he regarded as a roué, whose main objects were to hoodwink Prussia, intimidate the smaller States and gain every point in the diplomatic game by lying rather than by straightforward methods. "Caricatures of periwig diplomatists" is the phrase with which Bismarck described to a friend the members of the Diet.

In such society Bismarck was not slow to show his teeth. No opportunity to ruffle Austrian complacency was neglected by him.

The growth of Bismarck's conviction that war with Austria must come if Prussia were to become a really great power, is evident in all his dispatches from Frankfort to Berlin between 1851 and 1859. When he left the Diet in the latter year to represent Prussia at the court of the Czar, he wrote to Baron Schleinitz: "I see in Prussia's relations to the confederation an infirmity which sooner or later we must cure ferro et igni." Fire and sword! Blood and iron! Such was his prophetic valedictory to the Diet.

Three years in St. Petersburg, a few months in Paris, and on September 28, 1862, Bismarck became the Prime Minister of King William of Prussia, later Emperor William of Germany. There was a deadlock between the king, who wished money to prepare his army for coming conflicts and the parliament, which refused to grant it. The king had been driven to despair. He was ready to abdicate.

"Will you help me rule without budget and without parliament?" he asked Bismarck, and Bismarck answered:

"Your Majesty, I will see that your rule without budget and without parliament." To the deputies he added: "If you will grant me nothing, I shall take the money where I can find it."

For four years he did this. The army was reformed and prepared for the battlefields where, with fire and sword, blood and iron, German unity was to be forged.

The first cause of the war between Austria and Prussia in 1866 was as old as the confederation of German States. Metternich and Schwarzenberg, who guided Austrian diplomacy during the first half of this century, considered it indispensable to Austrian power and prestige that Prussia be abased or abolished. Every effort of Prussia to acquire influence corresponding with her military strength was thwarted by Austria in alliance with the smaller German States, which felt that a Prussian great power would menace their independence.

To end this degradation of his country Bismarck slowly, cautiously, and firmly shaped the Schleswig-Holstein quarrel into a casus belli. This quarrel in diplomacy was like Jarndyce vs. Jarndyce in law. Its history reached back into gray antiquity. For years it had been a source of friction between Denmark and the German Confederation. Conferences and protocols had failed to settle it, and historical research had but tightened the tangle. Lord Palmerston said that only three men had ever understood it—one of them had died, the other had gone crazy, and the third, himself, had forgotten the solution. The duchies of Schleswig and Holstein, although attached to the crown of Denmark, were more German than Danish. Their people were represented in the Diet at Frankfort. They had, moreover, well defined rights to constitutions and, in certain cases, to a dynasty of their own. A large Danish party wished to unite the duchies more closely with the kingdom, and in so doing to ignore these rights. The duchies became rebellious. Bismarck felt that the time had come to begin enlarging Prussia and increasing her power, to begin humbling Austria and obtaining for Prussia the supremacy in North Germany. In the diplomatic campaign toward these ends he had displayed as never before or after his genius for international politics. Bent on war from the first, he had shown every regard for old international agreements as to the peaceful settlement of the question. By deference to Napoleon's desire for conferences and by apparent assent to Napoleon's proposals of a future Franco-Prussian alliance, he had avoided the hostility of France. By his strict adherence to the letter of a peace policy, he had disarmed Russian and English interference with the sword.

At the same time he had been dragging along as an ally of Prussia unwilling Austria, who, although quite indifferent to the fate of Schleswig-Holstein, feared for her influence in the confederation in case she allowed her northern rival to struggle alone for the popular cause of the duchies. Toward the Danes he had adopted merely a waiting policy, sure that the Copenhagen patriots would soon force the government to the crisis. Toward the Schleswig-Holstein rebels his attitude had been one of benevolent tolerance.

Early in 1864 the course of the Danish patriots had passed the bounds set by the protocols and conferences, for which Bismarck had professed such respect, and Prussian and Austrian troops entered the Duchies. On April 18 the Danes were driven from the intrenchments at Dueppel, and Prussia and Austria were in possession of Schleswig and Holstein. The first result of the war was joint occupation of the Duchies by the two powers. The second result was constant friction between Prussia and Austria. The people of Schleswig-Holstein wanted one thing, Bismarck wanted another, and Austria wanted anything like a settlement that she might be left free to care for her troublesome domestic affairs.

In "The Founding of the German Empire" Heinrich von Sybel devotes a volume to the details of Bismarck's masterly policy between the war with Denmark in 1864 and the war with Austria in 1866. With all his reputation for madness, Bismarck did not allow the crisis to come before he had made sure that Austria would have no allies. A dozen times in those two years only a word was needed to make a war, but the man of blood and iron bided his time. Not until he had assured himself of French and Russian neutrality, not until he had closed an alliance with Italy, eager to expel Austria from her provinces and to be united, did he clear the way for the conflict in arms. Moreover, he left to Austria the odium of the final move. On June 14, 1866, Austria passed in the Frankfort Diet a motion to mobilize the troops of the confederation against Prussia. Then Prussia withdrew from the confederation. Central Europe was filled with the clatter of arms. The completeness of Prussia's preparations, to which Bismarck had timed his diplomacy, was at once evident. Within two days Prussian armies were in Hanover, Hesse, and Saxony. Within three weeks 200,000 Prussian soldiers confronted the Austrian main army in Bohemia. Within a month the Prussian vanguard camped in view of St. Stephen's. Austria was smitten hip and thigh, her power in North Germany was crushed, and the foundation of the North German Union was laid. King William held the sword which, on the battlefield of Koeniggraetz, cut clear Prussia's way to independence and power, but Bismarck, and Bismarck alone, had tempered it for four years in the heat of domestic conflict, had pushed back the hostile hands stretched out to keep it in its sheath, had selected its foeman, and had timed its fall.

"We are getting on well," wrote Bismarck to his wife three days after the battle, "and if we do not carry our demands too far or think we have conquered the world, we shall obtain a peace that will be worth the pains." In these words he referred to his struggle with the generals and the king, who, angered by Napoleon's interference in behalf of Austria, were ready to march to the Rhine and begin another war. Bismarck regarded war with France as inevitable, both from the Prussian and the French point of view, but he wished to wait until Prussia, with her armies unworn by recent service, could take the field with a host of allies and march to certain victory. His counsel for moderation prevailed. Prussia contented herself with the annexation of Hanover, Schleswig-Holstein, and some odds and ends of German territory and with the formation of the North German Union. But the moment peace was concluded, Bismarck began preparations for the conflict with Napoleon. He secretly made offensive and defensive alliances with the South German states, assured himself of Russia's friendship, and kept clear Prussia's understanding with Italy. He then felt himself strong enough for the supreme struggle by which he hoped to establish the German Empire.

Napoleon desired compensation for his neutrality in 1866. He believed that the balance of power had been disturbed by the rise of the North German Union. The war party in France thought that the glory of French arms had been dimmed by the achievements of Prussian soldiers in Bohemia. The French people generally longed to extend their territory to the left bank of the Rhine. The men at the head of German affairs were hardly less belligerent. All Europe saw the conflict gathering from month to month.

On July 4 Spain announced to the world that Leopold of Hohenzollern-Sigmaringen, a prince of the Prussian royal house and a colonel in the Prussian army, was to become her king. The swift reply from Paris was "Never!" Strong protest from the French government caused Leopold to retract his acceptance of the throne. Not satisfied with this, the French Emperor demanded that King William sign a letter expressing approval of Leopold's retraction and pledging himself never again to allow Leopold to be a candidate for the Spanish throne. The king refused. Just at this critical point Bismarck stretched out his hand.

The fall of the sword had been timed well for King William. Had Bismarck hesitated, the Austrians would have been mobilized to help the French. As it was, the German armies were across the Rhine almost before the rest of Europe could realize what had been done.

Bismarck went to the war in yellow uniform with white cap and top boots. He followed his king on the battlefield, and in camp worked until 2 and 3 o'clock in the morning, despite all fatigues of the day, in reading, writing, and dictating dispatches. He was the chief of a devoted but motley band, who became known as "Bismarck's people," and wherever his tent was pitched there gathered a remarkable crowd of his secretaries, privy councilors, cipherers, newspaper correspondents, cooks and couriers. As a diplomatist he showed all his blood and iron. In 1866, with Germany divided against him, he had been the soul of caution. Now with all Germany behind him, he was ready to stand against the world in arms before yielding a dot of German rights. In 1866, when France alone strove to help the vanquished enemy, he had given the soft answer. Now, when all the neutral powers except Russia were eager to save France from the extreme misfortunes of war, he replied sternly that Germany alone had conducted the war and alone would settle the terms of peace, regardless of attempted intervention from whatever source. On January 18, 1871, the German Empire was proclaimed; on May 10 the treaty of Frankfort was signed; on June 16 the German troops made their triumphal entry into Berlin. Fire and sword had done their work. Bismarck's diplomacy was triumphant.

Bismarck was Chancellor of the new empire as he had been Chancellor of the North German Union. In foreign affairs his one aim was to make secure for Germany what she had gained on the battlefield. "We do not want another inch of territory," he said. He bound Austria and Italy to the empire by the triple alliance. He fostered friendly relations with Russia. He completely isolated France and rendered impotent her longing for revenge and the lost provinces.

In the domestic politics of the empire Bismarck was less successful. The treaty of Frankfort was hardly three months old when he challenged the Roman Catholic Church to mortal combat. Roman Catholic prelates had tried to force upon Catholic priests and prelates the doctrine of Papal infallibility. Bismarck replied with laws intended to mark clearly the dividing line between the offices of the Church and the offices of the State.

Then came the expulsion of the Jesuits from the German Empire, and the blows at the Church and Vatican followed thick and fast. The German ambassador at the Curia was withdrawn. Editors of Roman Catholic newspapers were prosecuted with renewed vigor. The Pope came to the aid of his German children with the declaration that the laws enacted in Prussia against the Church were "null and void." Bismarck responded with the "bread basket law," which cut off the pay of rebellious clergymen. The conflict continued unabated for two or three years more.

In 1878 Pope Pius IX. died, and was succeeded by Leo XIII. Slowly and diplomatically Bismarck began his retreat, and finally in 1887 he had the Prussian parliament do away with almost the last vestige of the anti-Catholic laws. He made a powerful speech in favor of the measures in question, and threatened to resign in case they should be rejected. He was at Canossa.

Bismarck's struggle with the Social Democrats began with the enactment of repressive laws against them in 1878. Two socialist fanatics had tried to kill the Emperor, and Bismarck was intent upon crushing Social Democracy. He did not do it. The Social Democratic vote, which had been but 351,000 in 1874, grew to 763,000 in 1887. The social democrats have attempted to unload upon Bismarck the odium of this increase, but as socialism has spread steadily in Germany since 1864 under all conditions of treatment and without respect of ministers or policies, they have proved only that he was unable to check a strong national movement.

Bismarck brought through the Reichstag also bills to increase the army, to protect more highly German manufactures and grains and to insure workingmen against destitution in old age or illness. He taught German officialdom how to work. He set in motion the whole machinery of the new State.

The list is not long, but every number on it cost mighty effort, too much effort for the strength of any other man in the empire. Bismarck, however, had marvelous power in the Reichstag. He was no orator. He despised eloquence. He often hesitated in his speech, sought with evident effort for a word or phrase and interlarded his cumbrous German with foreign terms. Yet in debate he was every inch a giant. When his great form rose from the Chancellor's seat and the wrinkles of his furrowed face deepened, and his shaggy brows drew down over his keen eyes, the air of the chamber was oppressed with forebodings and fears. His hatred was a scourge to those who were against him. The fight was his natural element, and he plunged into it. His onslaught was terrific. Deputies quailed before it. Men who had sat with him in the ministry fled from the house to escape it. Soldiers who had fought behind the barricades in Berlin bent under it and wept. Bismarck knew no pity. No penalty was too severe for one who opposed him.

Emperor William died on March 9, 1888. Bismarck had served him with feudal loyalty and mourned for him as a subject rarely has mourned for a sovereign. The short reign of Emperor Frederick followed, and then the present Emperor ascended the throne. "He will be his own Chancellor," said a French writer prophetically. On March 18, 1890, Bismarck fell.

In the summer of 1895 the sculptor Schaph, of Berlin, who made the Bismarck statue at Cologne, took measurements of Bismarck's head by the rules of anthropometrics, and found that his cranium had a capacity of 1,965 cubic centimeters. His brain, it was said, should weigh 1,867 grammes. The estimate put the weight of his brain at 35 per cent. above that of the average adult European. The horizontal measurement of his head from the frontal bone to the occiput was 212 millimeters, or more than 8·35½ inches, and that from temple to temple 170 millimeters, or more than 6·69 inches. Only one head out of 2,500 measured at Baden Baden exceeded 200 millimeters in horizontal measurement from front to back, and the average of the similar measurements of the thirty members of the National Science Society at Carlsruhe was 195 millimeters.

When Bismarck's eighty-first birthday was celebrated in 1896, there was talk of a reconciliation be-

tween the prince and his sovereign. The Emperor sent his photograph to Bismarck, the latter returned thanks, and little by little the way was paved for a meeting between the two men, and eventually for the visit which the Emperor paid to Bismarck at Friedrichsruh some months ago.

From the beginning of the present year Bismarck was constantly under the surveillance of his physicians, and, whatever it may have been called, his life was that of an invalid. Few persons was allowed to see him, and every precaution was taken to prevent any disturbance of his rest and quiet. This was in a measure the result of the experience of a Hamburg reporter who went to Friedrichsruh to inquire after Bismarck's health and was received by Count Rantzau in such a way that the reporter won a suit for damages from the Count. He contributed only two articles to his organ, the Hamburger Nachrichten, during the past year. These were dictated to the editor, who came to his house. He sent many memorandums to the editor, however, and these he usually dictated to his private secretary. Dr. Chrysander used to read the papers to him, and learned Russian for the purpose of translating to him articles from the two principal newspapers of St. Petersburg. In addition to these—which he sometimes through his small knowledge of Russian was able to read in the original—Bismarck regularly read three London newspapers.

He usually rose late, ate a hearty breakfast without the accompaniment of tea or coffee, but frequently including as much as a pound of meat. He always took this alone, reading some of his mail at the time. He was abie to ride out only a few times last spring, and then for only a brief period. Last January he undertook what was for him unusual exertion. He stood as godfather to twins born to one of the workmen in his sawmill. This was done in order to show the other workmen, who are largely socialists, how much he appreciates the services of his more faithful employes. The dinner hour was with him the principal event of the day, although the number of guests was limited. One glass of Moselle wine at dinner and two of beer after dinner constituted his allowance in recent months. He obeyed this restriction generally, but on one occasion so far broke his regimen as to drink five bottles of Moselle and as much beer as he wanted.

His political interests during the last years of his life were almost wholly confined to his own country, and the war between Spain and the United States, as well as other questions of foreign politics, are said to have had but little interest for him.

Bismarck left two sons. Count William is a country squire. Count Herbert has tried public life and failed. With the death of the Iron Chancellor the political dynasty of Bismarck became extinct.—For our engraving we are indebted to L'Illustrazione Nazionale and for our article to The New York Sun.

## THE ARMED STRENGTH OF EUROPE.

### TABLE SHOWING RESOURCES IN THE EVENT OF A GENERAL CONFLICT.

THE military and naval statistics embraced in the following tables were specially prepared for the World Almanac by Lieutenant W. R. Hamilton, Fifth Artillery United States Army, and corrected from the latest official reports on file at the War Department, December, 1897.

LAND FORCES.

| CLASSES | Germany. | France. | Italy. | Austria-Hungary. | Russia. | Great Britain. * | Turkey. |
|---|---|---|---|---|---|---|---|
| ACTIVE ARMY & RES. | | | | | | | |
| Officers | 22,672 | 22,980 | 18,400 | 17,316 | 28,700 | 4,918 | 9,262 |
| Non-com. Offs. & Men | 1,946,380 | 2,020,400 | 698,320 | 862,300 | 1,116,824 | 215,281 | 180,600 |
| Non-combatants | 171,300 | 28,600 | 12,000 | 13,611 | 38,000 | 11,600 | ..... |
| Horses | 108,800 | 112,000 | 55,800 | 63,500 | 163,000 | 29,812 | 30,400 |
| Guns | 2,964 | 3,400 | 1,572 | 2,072 | 720 | ..... | 696 |
| Vehicles | 31,500 | 34,000 | 12,892 | 17,000 | 27,313 | ..... | ..... |
| FIRST RESERVE. | | | | | | | |
| Officers | 22,340 | 18,800 | 17,600 | 16,840 | 17,300 | 143,000 | 12,000 |
| Non-com. Offs. & Men | 2,183,400 | 1,886,412 | 573,000 | 361,000 | 2,513,900 | | 460,000 |
| Non-combatants | 4,652 | 14,000 | 3,500 | 2,800 | 16,000 | ..... | ..... |
| Horses | 92,400 | 80,200 | ..... | 23,240 | 132,718 | ..... | 60,000 |
| Guns | 1,624 | 1,544 | 744 | 1,200 | 3,412 | ..... | ..... |
| Vehicles | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| SECOND RESERVE. | | | | | | | |
| Officers | 19,380 | 18,980 | 18,470 | 22,620 | 18,920 | 274,604 | 490,000 |
| Non-com. Offs. & Men | 968,400 | 912,000 | 856,000 | 486,511 | 1,312,640 | 19,600 | ..... |
| Horses | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Guns | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| GRAND WAR TOTAL. | | | | | | | |
| Officers | 68,412 | 60,760 | 54,470 | 57,276 | 64,920 | 637,863 | 1,061,862 |
| Non-com. Offs. & Men | 5,098,180 | 4,788,812 | 2,127,320 | 1,709,811 | 4,943,364 | ..... | 90,600 |
| Horses | 201,200 | 192,200 | 55,800 | 86,740 | 295,718 | ..... | 696 |
| Guns | 4,588 | 5,024 | 1,986 | 2,712 | 6,084 | ..... | |
| PEACE EST'LISHM'T. | | | | | | | |
| Infantry | 396,612 | 378,612 | 141,612 | 189,300 | 487,600 | 148,147 | 148,618 |
| Cavalry | 68,400 | 70,108 | 26,800 | 36,700 | 112,300 | 19,536 | 30,000 |
| Artillery | 86,316 | 84,640 | 34,114 | 35,862 | 110,444 | 37,124 | 18,456 |
| Engineers and Train | 25,980 | 26,000 | 13,709 | 15,300 | 32,600 | 15,392 | 28,700 |
| Horses | 119,700 | 118,000 | 58,760 | 67,400 | 176,600 | ..... | 33,400 |
| Guns | 2,964 | 3,480 | 1,986 | 2,712 | 2,672 | 720 | 696 |
| TOT. PEACE EST'M'T. | | | | | | | |
| Men | 607,308 | 559,260 | 216,235 | 277,192 | 1,743,244 | 220,199 | 228,574 |
| Horses | 108,800 | 192,200 | 58,760 | 67,400 | 176,600 | ..... | 33,400 |
| Guns | 2,964 | 3,480 | 1,986 | 2,712 | 2,672 | 720 | 696 |

This table does not include fortress guns. * Including 78,043 in India and 33,600 in colonies.

| CLASSES. | Spain. | Belgium | Netherlands. | Denmark. | Greece. | Switzerland. | Sweden and Norway. | DANUBIAN STATES. Bulgaria. | DANUBIAN STATES. Servia. | Roumania. |
|---|---|---|---|---|---|---|---|---|---|---|
| Infantry | 64,314 | 32,970 | 42,918 | 24,720 | 13,824 | 118,243 | ..... | 22,411 | 51,300 | 32,150 |
| Cavalry | 14,514 | 6,940 | 4,676 | 2,100 | 1,262 | 3,576 | ..... | 2,400 | 7,940 | 2,110 |
| Artillery | 11,605 | 8,252 | 12,800 | 9,820 | 2,320 | 9,712 | ..... | 4,611 | 9,112 | 1,611 |
| Engineers & T'n | 5,102 | 2,512 | 1,874 | 1,080 | 6,186 | 6,300 | ..... | 1,820 | 2,100 | 2,460 |
| T'l Active Army | 84,335 | 50,674 | 62,468 | 27,720 | 23,592 | 137,833 | 38,840 | 31,242 | 64,152 | 38,331 |
| E. Indian Tr'ps | ..... | ..... | 37,300 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Sanitary & Administrative T'ps | 28,700 | 4,265 | ..... | ..... | 372 | 4,342 | 1,600 | 1,400 | 1,300 | 2,106 |
| W. Indian T'ps | * 201,312 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Philippine Tr'ps | 37,700 | ..... | 1,826 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1st Reserves | 160,000 | 64,300 | 54,600 | 41,416 | 98,000 | 81,000 | 90,000 | 83,700 | 41,300 | 82,100 |
| 2d Reserves | 1,000,000 | 51,800 | 78,000 | 48,000 | 176,000 | 270,000 | 125,000 | 110,000 | 164,318 | 130,000 |
| T'l Peace Str'th | 352,197 | 54,839 | 101,594 | 27,720 | 23,964 | 142,175 | 40,440 | 32,642 | 65,452 | 40,437 |
| T'l War Str'gth | 1,512,197 | 170,939 | 234,194 | 117,136 | 297,964 | 493,175 | 255,440 | 226,342 | 271,170 | 250,537 |

* Army in Cuba, September, 1897, and also including 6,000 in Porto Rico.

### CONDITIONS OF SERVICE AND AVAILABLE STRENGTH OF POWERS.

Every year the young men who attain the age in which they are available for military service are enrolled, in advance, in every European country. These ages run generally from 21 to 45, and this time is divided up by service: first, in the active army which answers to our regular establishment; second, in the reserve to the active army; third, in the Landwehr; fourth, in the Landsturm, in which they are never called out, except in time of war, and then for defense of the fatherland only.

Austria-Hungary.—The registered number of young men attaining the age of military service in 1896 was 344,300. After exemptions, postponements, etc., the number fit for service was found to be 186,700. Of this number 126,000 were drawn for service, as in 1895, namely: Army and navy, 103,000; Landwehr, 23,000. Obligatory service commences on the first day of January of year man attains 21 years. It is three years in active army, seven in active army reserve, and two years in Landwehr. The rest of his time up to the end of his forty-fifth year is in the Landsturm.

France.—Registered number of young men for 1896 was 339,780. After exemptions, deductions, etc., there remained 255,400 fit for service, plus 74,000 postponed from former years. Liability to service is on all classes of citizens in the republic equally. It commences with the twentieth year and continues for twenty-five years. Three years are with the colors or active army, the next ten with its reserve, the following six in the territorial reserve army, and last six in its reserve.

Germany.—The registered number of young men for 1896 was 437,800, and numbers required to fill annual contingent was 242,000. There were also in addition 9,400 one year volunteers. Liability commences with end of the seventeenth year and ends with beginning of forty-fifth year. It is termed "Wehrpflicht." It is divided into classes, "Dienstpflicht" and "Landsturmpflicht." In English the above would be "Service Liability" and "Landsturm Liability." The soldier first enters active army for two years. He then has a leave of absence for five years, during which time he is called out for two trainings of eight weeks each. He then goes for five years in first ban of the Landwehr, where he is called out for two trainings of two weeks each. He then passes into second ban of Landwehr, where he remains for five years. The rest of his time is passed in the Landsturm.

Italy.—There were 279,340 youths registered in 1896, and of these but 96,000 were drawn, the rest being exempted or excused. But exemptions of former years to the number of 154,000 were added. Service is universal and lasts for nineteen years. The first service is with the colors for two years. The soldier then goes on leave till the end of his thirteenth year, during which time he is called out for thirty days' service each year. The remaining six years are passed in the reserve of the territorial militia.

Russia.—The registered number for 1896 was 937,400, of which 278,000 were placed in service. Service is active and with reserve. In active army soldier remains for five years, then passes into active army reserve for thirteen years. In reserve there are two bans, and all not included in ban just referred to are placed in second ban. Service lasts eighteen years. All men in the empire not in active army or its reserve constitute the militia, and remain in it from twenty-first to forty-fifth year, and are given three years of home training, but are called out for war at any time.—World Almanac.

## PAPER ENLARGEMENTS.

THE man who essays enlarged negatives should not confine his efforts to glass, otherwise he misses some new and delightful experiences and effects.

Once over the initial stages, there is something very pleasant about the making of enlarged paper negatives; the work simplifies itself into the mere exposure and development of "bromide" prints, a branch of the art known in some degree to the veriest tyro; the only detail of the manipulations likely in any way to embarrass the worker being the final process of waxing the negative.

One simple but sufficient reason why one should not altogether neglect this department of photography is the fact the dry plates of the larger sizes are not to be readily purchased in the average town, nor are they, if purchasable, entirely free of suspicion as regards age; whereas bromide paper will usually be found in the shops in rolls and fresh enough for the purpose; the point is debatable, but I think on the whole, if it was a case of "Hobson's choice," I should prefer old paper to old plates.

Any arrangement in use for enlarging may be adopted. I much prefer the old simple and cheap method of enlarging by daylight in the old familiar way of a blocked window, with north light and with ground glass screen and reflector for use, as they generally will be. The apparatus may be simple and homely, almost any old bellows camera will do to carry the lens, but the latter must be one giving good definitions, provided with stops and of focus not greatly exceeding the length of plate to be enlarged; the mechanical contrivance for holding the paper must be in alinement with the optical arrangements; the operating room must be for a time a perfect dark room or rather as much like the inside of a big camera as we can imagine it to be; the transparency from which we design to make the negative should be of good color, sharp, clear, clean, and not too dense; in as many words, the more perfect the picture from the technical point, the better chances of a successful result.

Presuming now that we intend to make enlarged negatives, measuring 20 × 16, which is a popular size and proportion, the first thing to do is to provide at least three trays. Wooden trays, neatly made, varnished inside and out, and enameled, are handy, light, and practically indestructible, if carefully used (I have had some in use for fifteen years). They are, moreover, cheap and easily made; they will not come to grief as do procelain dishes at the first blow, and, unlike the glassed-bottomed variety of tray, the most dismal invention of the past two decades, they won't "let everything through," if you, in the sepulchral darkness of the developing room, suddenly mistake the jug or bottle for the work table; a man who can pass through a calamity of this kind without profanity has qualifications which should lead him to the episcopal bench. However, the trays should be of ample size; it is a good plan to make 20 × 16 negatives on sheets measuring the full size of 23 × 17, trimming down after they are finished and waxed. The trays being perfectly flat do not lead to waste in the matter of developing solutions.

Some preliminary trials will be advisable with regard not only to exposure and development, but waxing. We may make these trials on the small scale, using the transparency, and making prints by contact; carrying the process through from beginning to end in this way, we shall be better equipped for work when we come to the more serious business of handling the large pieces of paper; exposures must be ample, and, allowing extra for the enlargement, should develop up as clearly and easily as in the smaller contact print. Especially is this experience useful when we are gageing the density of our negative print; this density should be quite two degrees more than in the case of a positive print; we must not only allow for the weakening effect of the "hypo" bath, but, after waxing, when you have rendered the paper transparent, there is the possibility of flatness in the resultant prints if the negative is not of normal density.

In the matter of development, or rather as to choice of developer, we may use hydroquinone, amidol, or a metol-hydroquinone solution; the developer should be used at first under strength, that is to say, diluted, building up the picture by the addition of stronger solutions, if necessary. It is, of course, very difficult to add to what has already been said many times upon the same point; as a fact, I may say that any standard hydroquinone or amidol developer will do for our purpose if moderately restrained or otherwise diluted; fixing, washing, and drying follow in the usual way. In all cases I find the better technical result by using a piece of paper a size larger than actually wanted; this allows for neat trimming up after waxing the negative.

A fourth dish or tray, this time of stout zinc, is used for the waxing process. A tray can be very readily made out of the zinc by measuring out the space required, bending down (using one side and end of a table as a guide) the sides and ends, squaring up the corners with a block of wood and mallet, afterward soldering them if thought necessary; a tray can be extemporized in this way in less than ten minutes, and quite good enough for the purpose.

Now for waving. In order to do this satisfactorily and with the least trouble and mess, make use of the domestic kitchen; there should be a good fire on the way, and no one about to interfere. Spread out in front of the stove two or three newspapers (they are not really necessary, but they serve to silence any feminine scruples), put the zinc tray in a warm place, and then melt in a pipkin, over boiling water, about a pound of clean paraffin wax—a cheap article, and one which can be used over again. Let the enlargements be perfectly dry. Now, in front of the fire place the print in the tray, pour over it the melted wax, and see that it is thoroughly saturated with the wax; of course, the tray must be hot enough to keep the wax liquid for a few minutes at least. This done, remove the print by two corners, lifting it out in front of the fire so that superfluous wax will drain off. As the print is gradually drained and withdrawn from the heat the wax sets, and by the time we have removed the enlargement to an adjacent table, is dry and finished, except for any trimming required. This all sounds rather like a greasy and messy business, but is not so at all.

It is quite possible to wax a dozen negatives in this way in less than half an hour, and without making any mess whatever. The room should be fairly warm, though, and the fire hot. The novice will possibly find it necessary to even his waxed negatives; he is apt to get too much wax on. This can be once more drained off in front of the fire, and then finish them between folds of blotting-paper under a hot iron.

It is impossible to make, by any mere arrangement of words, the waxing of paper negatives at all attractive. The mere word is suggestive of mess and discomfort. This is unfortunate, for many are deterred by reason of it from attempting an easy and satisfactory process of enlarging. If nicely made, paper negatives are as satisfactory in the work room as glass, possibly

more so, and are certainly as lasting, while for lightness and convenience of storage they are infinitely better.—J. P. Nott, in Br. Jour. of Photo.

## SOME INTERESTING ROWING EXPERIMENTS.

By E. CUTHBERT ATKINSON, in Natural Science.

IN the autumn of 1895 the author designed an indicator for recording the work done in a stroke of rowing.* The apparatus replaced the front thowl of the rowlock and consisted of a plate turning with the oar, which pressed against it, about an axle to which it was connected by means of another plate pivoted to the first.

The pressure of the oar tended to move the front plate back toward the axle, this motion being resisted by a spring. The movements of the plate, and consequently of the oar, were recorded as a diagram on a horizontal card by a pencil connected with the plate. This diagram afforded the information given by the familiar steam engine indicator diagram, and gave measures of the horse power of oarsmen, as well as interesting information with regard to the way in which the work was done, showing the great differences that existed between the style and stroke forms of different oarsmen.

The successful working of this simple instrument encouraged the author in 1896 to attempt another, obviating the shortcomings of the first. This latter, in addition to various mechanical imperfections, had the disadvantage of giving the diagram in curvilinear co-ordinates, necessitating laborious measurement and reduction before stroke form and work done could be estimated.

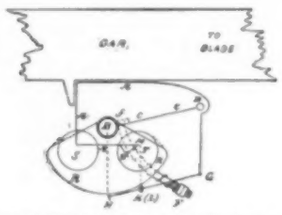



FIG. 1.—DIAGRAM ILLUSTRATING ACTION OF PENCIL AND SPRING.

Further, in testing a steam engine it is customary to take several diagrams during a run by changing the card on which the figures are being drawn. In a boat this is impracticable without stopping the rowing. It will be seen that an important part of the later machine is the automatic winding apparatus, whereby the card changes itself. The author was recently interested in having his attention called to a similar device which was being introduced for the steam engine.

The general principle of the former indicator, that of recording the movements of a plate turning with the oar and pressed forward by a spring, has been adhered to. In the half-tone engravings and diagram illustrating the action of the pencil and spring (Fig. 1) the face, *A*, moves with the oar, and is connected with the axle, *B* (which screws on to the rowlock in place of the thowl), by means of the link, *C*. This junction piece, which is strongly braced to avoid flexure, rotates round the axle in an adjustable bearing and is pivoted to the face at *D* in dead centers. The spring is placed between *E*, on the back part of the front plate, and a nut at *F* on a core, fixed at *f* to the link.

The part of the instrument in which it differs essentially from the earlier one is the recording mechanism, in which the diagram is obtained practically in rectangular co-ordinates, and every fifth stroke is automatically indicated for a period up to 500 strokes.

The diagram is recorded on a drum, *R*, having its axis along the axle. The strip of "metallic paper" on which the diagram is drawn winds off the cylinder, *S*, over the drum onto the cylinder, *T*, and is held in position by an elastic thread which winds off a pulley on *T* onto a similar pulley on *S*.

The pencil attachment, *HGL*, moves as a whole about a vertical axis, *G*, fixed to the face, while the arm, *GH*, can move about a horizontal axis fixed to the main attachment, which keeps it in a vertical plane with the pulley, *L*. *G* is so placed that (Fig. 1) *BDGH* is a parallelogram (assuming for the moment that *H* has no vertical movement), and, consequently, if *H* remains on the drum while the face moves parallel to itself toward the axle, it will stop in the same position. The pencil, *H* (a brass point), is pressed upward by a spring, and is held down by a chain which passes over the pulley, *L*, and is fixed to the face at *M*.

If the front face moves backward parallel to itself, *G* and *M* participate in the movement, while *H* rests on the drum owing to the spring, which, keeping the chain tight, pulls *L* toward *M*. Consequently, *M* approaches *L*, and some of the chain passes to the vertical part and allows the pencil to move upward. In this way a pressure line is drawn, which is a circle about *G* as center. The maximum error introduced into the position of the oar by regarding this as a straight line is about 0·5°,* while the line of no pressure produced by simply turning the oar is a horizontal circle, which becomes a straight line when the diagram strip is unwrapped.

At the conclusion of a stroke, when the pencil has reached its extreme position to the right, the oar leaves the face and rests against the opposite thowl, only touching the instrument at the rounded end of the face to carry it into position for the next stroke. During this movement the pencil travels over the base line and a lever, *N*, engages a spoked wheel, *O*, which gears into the right hand cylinder and winds the strip into a new position. As the winding ceases, a cam wheel, *P*, is rotated; this drives a plate attached to the bottom of the drum outward, and thus lifts the pencil off the strip and the winding lever out of gear.

During the stroke the wheels are not engaged, since the levers share the backward movement of the face when the spring is compressed and pass clear of the wheels. While the cam holds the plate out, no diagrams are drawn and no winding goes on. Each forward swing carries the cam wheel forward one tooth, until at the fifth stroke the pencil again reaches the paper, another diagram is drawn, and the strip is once more wound. Two cords place the starting and stopping of the record under the control of the coxswain. The upper part of the instrument is protected from splashing or rain by a cover.

Knowing the diameter of the drum and the strength of the spring, the diagram gives a result in pounds pressure per degree of turn of the oar. In order to express the result in foot-pounds of work, the ratio of the pull on the handle of the oar to the corresponding pressure on the rowlock must be known, and the distance through which the handle moves per degree of turn. These two constants are found from the in and outboard dimensions of the oar and the position of the center of pressure of the water on the blade.† The

$$= 3\left(1-\cos\sin^{-1}\tfrac{1}{16}\tfrac{3}{5}\right)\times\frac{360}{2\pi\times 2}$$

† Neglecting the moment of inertia of the oar about its button.

The axle of the indicator is 1 inch below the button. Midway between the hands is 41·5 inches above this point, and the tip of the blade is 102 inches below it. The center of pressure of the blade was calculated on the rough assumption that the pressure at a point varied as the velocity, and it was further assumed that the turning point occupied its mean position 36 inches above the tip.

The center of pressure thus calculated is 9·6 inches above the tip.

$$\text{Hence (see Fig. 13)}\quad \frac{P}{83}=\frac{F}{184}=\frac{R}{267}$$

The instrument was calibrated against a spring balance, using a lever with a mechanical advantage of 3·07, and a series of experiments with the spring used throughout showed 1 inch on diagram = 319 pounds pressure or a pull of 220 pounds.

The radius of the drum is 2·02 inches, so that 1 inch of base line on the diagram represents motion of $F = 1{\cdot}71$ feet.

$$\text{Finally, 1 square inch of diagram represents } 319\times\frac{184}{267}\times 1{\cdot}71 \text{ or } 377 \text{ ft. lb.}$$

spring was calibrated in the Millard Laboratory, Oxford, by kind permission of Rev. F. J. Jervis-Smith. With the oar and spring used in the experiments, a height on the diagram of 1 inch represents a pull of 220 pounds, and 1 square inch represents 377 foot-pounds.

When the indicator is fully open, it is usually convenient to have the spring under some initial compression. This is estimated by noting the turns given to the nut, *F*, after it has just touched the spring, and allowed for by measuring heights from a new base line 0·06 inch per turn below the actual one. Experiments in calibrating the spring showed that one end did not completely "bed" itself until some pressure was exerted. The error due to this is practically eliminated by raising the base line 0·03 inch.

In order to prevent the necessary length of the strip being excessive, the diagrams are made to overlap (Fig. 2). If the strokes are flat at the top, it is frequently

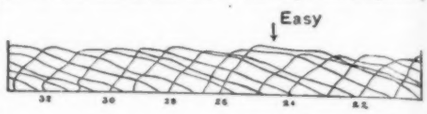



FIG. 2.—PART OF AN INDICATOR CARD. (Two-thirds actual size.)

not easy to determine at sight which is the "finish" corresponding to a particular "beginning." This is, however, discovered at once by measuring the length of the first or last stroke, from which the approximate distance of the "finish" from any "beginning" is known. A stroke thus individualized can then be measured up. The measurements taken are:

1. Length of stroke in degrees, which is afterward reduced to distance moved through by the handle of the oar.
2. Greatest height of diagram.
3. Area, measured with an Amsler planimeter.
4. The shape of the curve gives the style of stroke.

To determine the style of an oarsman under any particular circumstances, the idiosynerasies of the strokes are eliminated by superposing several diagrams (Fig. 3), and then drawing a mean line through the result.

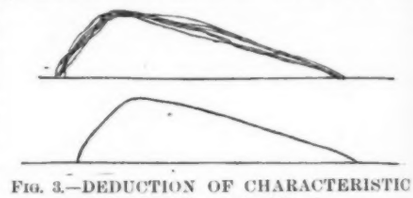


FIG. 3.—DEDUCTION OF CHARACTERISTIC DIAGRAM. (Actual Size.)

In this way the "characteristic diagram" is obtained. Similarly, in finding an oarsman's power, the mean of several stroke measures is taken.

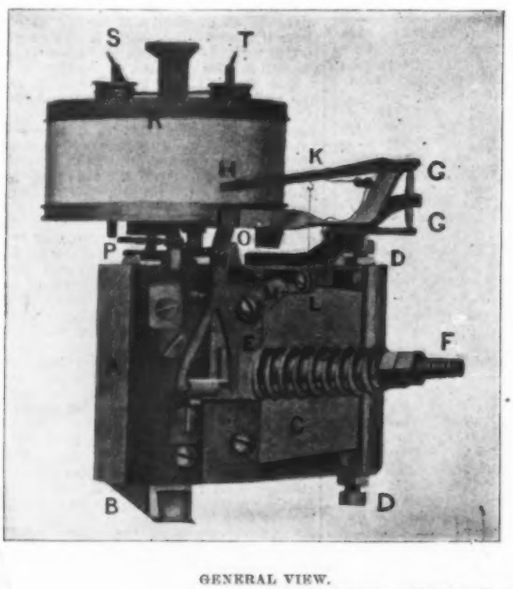
Having now described the indicator, the diagram, and the method of treating it, some account will be given of the results obtained from twenty-seven experiments involving some two thousand strokes of rowing. The principal oarsmen experimented on are denoted by *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *I*.

Fig. 4 represents a series of characteristic diagrams of rowing on sliding seats. *K* was obtained with the earlier indicator, but is introduced here, as the stroke form differs from any others in no small degree. This stroke, although very short, is, nevertheless, very powerful.

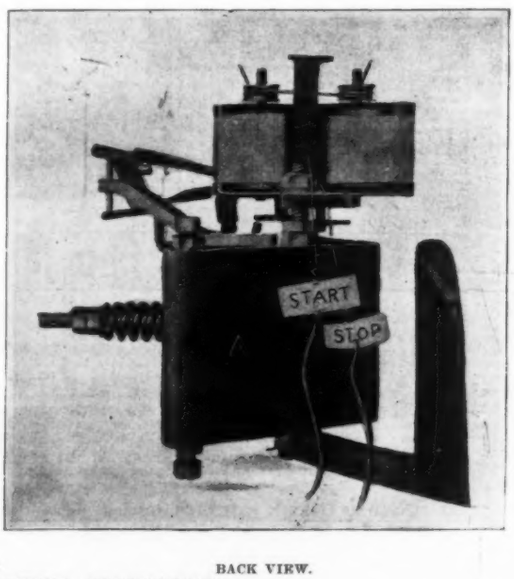
The horizontal dotted line corresponds to a pull of 100 pounds and the vertical one to a stroke length of 80°.

Four fixed-seat characteristics are shown in Fig 5. The results given in the table are generally deduced from a

* For a description of the instrument and results obtained, see Natural Science, vol. viii., pp. 178-185, March, 1896.




GENERAL VIEW.




BACK VIEW.

RECORDING INDICATOR FOR ROWING EXPERIMENTS.

Continuous Record Indicator, with Cover Removed, to show Pencil Attachment and Drum. *A*, front plate; *B*, bottom of axle; *C*, link; *D*, dead centers for link; *E*, plate end of spring; *F*, core and link support of spring; *G*, vertical axis of pencil attachment, but horizontal axis just above; *H*, pencil; *K*, *L*, *M*, chain; *L*, pulley; *N*, winding lever; *O*, winding wheel to left of this; *P*, cam for putting pencil out of action; *R*, drum on which diagram is drawn; *S*, *T*, cylinders holding paper.

larger number of measures than the diagrams, and in some cases additional experiments have been introduced, so that the correspondence between the figures and table is not necessarily exact.

An inspection of the characteristics reveals the great individuality in stroke-form that exists even among men who have rowed together and undergone the same course of instruction, and using the same boat and oar. Two diagrams could scarcely be more different than *B* and *F*. The author has found that the form *B* is rather typical of the heavy man's stroke—a

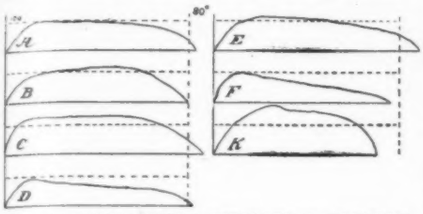



FIG. 4.—SOME CHARACTERISTICS—SLIDING SEATS.

powerful stroke, but with a sluggish beginning, while *F* typifies the light man who has a smart beginning, and quickly reaches his highest pressure, which he lacks strength to continue through the stroke.

A comparison of the sliding seat with fixed seat strokes shows that the latter generally have a much weaker finish, suggesting that the chance of good leg-work at the finish is diminished on a fixed seat. As is to be expected, the strokes are some 8 inches shorter. This shows—as an oarsman well knows—that a 14-inch

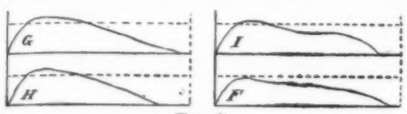



FIG. 5.

slide does not add its full length to the stroke, since the "swing" in sliding seat rowing is rather shorter than on a fixed seat.

In the table, results are shown of the experiments relating to work done in a gig pair, both on sliding and fixed seats. The author regrets that the stroke rate was not taken in more cases, it having been measured in only seven of the experiments. It is, however, not far from the truth to assume that the estimated rates in other cases are not in error more than one stroke a minute.*

The trials involved in the table have all been short, ranging from one to ten minutes, and speaking generally a similar rate of working, with a gradual fall in power, could have been continued for some twenty minutes, while, at high pressure, exhaustion would ensue under similar conditions in less than ten minutes.

ROWING IN GIG-PAIR

Average time between easies—3 min.

Average stroke-rate—22.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Oarsman | Stroke length in feet. | Ft.-lbs. per str. | Pull. Max. | Pull. Mean. | Mean. Max. | Horse-power. |
| I. Sliding Seat. | | | | | | |
| A | 4·9 | 381 | 99 | 77 | ·78 | 0·254 |
| B | 4·9 | 418 | 115 | 85 | ·74 | 266 |
| C | 5·2 | 571 | 128 | 110 | ·86 | 380 |
| D | 4·9 | 267 | 90 | 54 | ·60 | 178 |
| E | 5·1 | 399 | 104 | 77 | ·74 | 272 |
| F | 4·6 | 340 | 111 | 73 | ·66 | 196 |
| [K | 4·2 | 498 | 166 | 119 | ·72 | 331] |
| Mean | 4·9 | 396 | 108 | 79 | ·73 | ·259 |
| II. Fixed Seat. | | | | | | |
| G | 4·5 | 370 | 127 | 83 | ·65 | ·247 |
| H | 4·0 | 336 | 128 | 85 | ·65 | 224 |
| I | 4·2 | 343 | 123 | 82 | ·67 | 227 |
| F | 4·5 | 312 | 125 | 70 | ·56 | 208 |
| Mean | 4·3 | 340 | 126 | 80 | ·63 | ·226 |

The table indicates that Man Power in rowing is about ¼ H. P. and varies with individuals and effort between 0·2 and 0·4 H. P. The author regrets that up to the present the only experiment in a racing eight was on an Oxford "Torpid" in its early days of practice. He suspects that during a race of eight to ten minutes' duration the power would vary between 0·3 and 0·7 H. P.

The figure given in the sixth column of the table is of some importance, since it roughly indicates the form of the stroke. This coefficient, found by dividing the mean pull during the stroke by the greatest pull, gives a measure of the uniformity of the pull. If the usual coaching maxim of "getting the full work on at once and carrying it out to the finish" were literally carried out, the stroke diagram would become a rectangle, and the coefficient unity.

It is, however, probable that the best results would not be obtained with a high coefficient, since the extra work done does not compensate for the additional fatigue, physical and nervous, involved in setting the muscles suddenly at their fullest tension. In addition to this physiological point there is the mechanical one that the efficiency of propulsion is greatest—other things being equal—when the oar is at right angles to the boat, since it is here that the smallest proportion of the work is devoted to generating kinetic energy in the water.

This question of efficiency of propulsion by oars has been made the subject of experiment by the author. To determine this it is necessary to know, in addition to the information afforded by the indicator diagram, the point about which the oar is turning at every part of the stroke. Since the rowlock is moving forward, and the tip of the blade backward, some point between these is neither moving backward nor forward. This point may be called the Turning Point.* A moment's consideration will show that this point changes its position during the stroke, since the blade first encounters "dead" water, so that the blade tip at first moves slowly, and the turning point is lower down the oar than a moment afterward when the water has been set in motion.

By attaching a float to different parts of the oar by a string, so that the float was immersed during the stroke, it was possible to estimate fairly accurately the mean position of the turning point, for which a position 36 inches above the tip of the blade was found, *i. e.*, a point only three inches above the top of the blade. This shows how comparatively slight is the motion given to the water, a point which will be more clearly brought out below.

In August of last year the author made an attempt to arrive at more exact results on this point by taking a rapid series of photographs of an oar in motion on the same plate, from a point vertically above the boat. Unfortunately, the only time available, about 3:30 P. M. on a cloudy afternoon, was not an ideal one for exposures lasting $\frac{1}{125}$ of a second. However, a photograph was taken from which it has been possible to determine some twenty positions, plotting out a whole stroke, with parts of the forward swing on each side (Fig. 6).

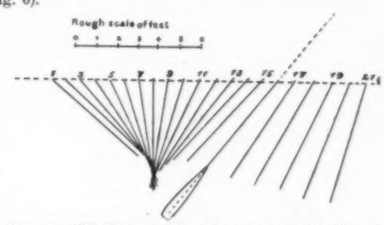



FIG. 6.—MOTION OF AN OAR DURING A STROKE.
(Boat is moving toward the right hand.)

The camera was fixed about 23 feet above the River Cam when there was practically no stream to vitiate the results. The exposures were made by a revolving shutter, having three slits, each with an angular width of 5° rotating before a slit of about double that width. The rotation was maintained by such a weight that the speed was fairly uniform during 120 exposures at about 14 exposures per second. As only 26 of the 120 were used, no serious error is introduced by considering the successive photographs taken at equal intervals of time.

Points were marked on the oar at the button, at 36 inches above the tip of the blade, and at the tip. The motion of these points is represented by the lines, *A*, *C*, and *D*, in Fig. 7. A projecting part of the bridge

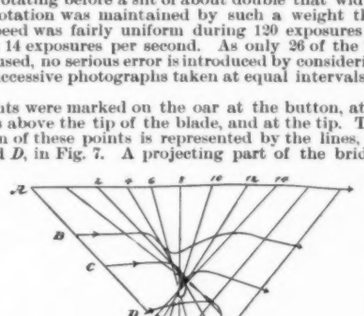



FIG. 7.—CURVES DESCRIBED BY POINTS ON THE OARS.
*A*, button; *C*, 36 inches above tip of blade; *D*, tip of blade.

from which the photograph was taken necessitated the camera being tilted slightly out of the vertical, so that there is a corresponding change in the scale of the picture in different parts, but as the important part is the loop of the line, *C*, this error is comparatively unimportant.

In Fig. 8, *A* represents the locus in space of the turning point determined as the "envelop" of the various oar positions shown on the photograph, showing that this point moves outward from the boat in a convex curve facing the bow of the boat.

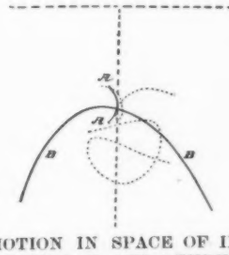



FIG. 8.—MOTION IN SPACE OF INSTANTANEOUS CENTER (*B*) AND "TURNING POINT" (*A*).

The curve *B* represents the Instantaneous Center Locus or point in space about which the oar turns bodily.

Fig. 9 represents the motion of the Turning Point along the oar. From this it will be seen that, starting from a point some 37 inches above the tip, it moves upward during the first part of the stroke as suggested above, but before the middle of the stroke a curious reaction sets in, and during the rest of the stroke the turning point steadily approaches the tip of the blade, indicating that the blade is coming more and more to rest.*

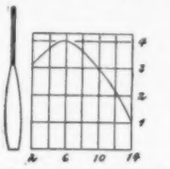



FIG. 9.—POSITION OF "TURNING POINT" ON OAR DURING STROKE.

This seems to show that at the beginning of the stroke the blade, which is increasing its distance (see curve *D*, Fig. 7) from the boat's side owing to diminished obliquity, sets up a swirl which moves backward in the path of the blade, but forward between that and the boat.

During the second half of the stroke the blade enters this forward moving water and has its motion retarded, taking up thereby some of the energy previously imparted to the water. This point requires further experiment.

In order to determine the efficiency of propulsion it is only necessary to find what proportion of the whole work done is developed as kinetic energy in the water. If the whole pressure of the blade against the water be *P*, while the center of pressure moves through a distance, *a*, perpendicular to the blade, the kinetic energy delivered to the water is $Pa$. For every small angle $\theta$ through which the blade turns while the turning point is at a distance $x$ from the center of pressure, the above product = $Px\theta$.

Without entering into details, the angles between successive positions of the oar, given in Fig. 6, were measured and corrected by interpolation from a curve, while corresponding values of $x$ and $P$ were found from Fig. 9 and *C* of Fig. 4 respectively.†

In this way it was found that almost exactly ⅓ (33·4 per cent.) of the work was left behind in the water as kinetic energy set up by the oar, giving an efficiency of 66·6 per cent. This efficiency coefficient is concerned, of course, only with the rowing mechanism, and takes no account of physiological waste of energy.

The mechanical efficiency is increased by increasing the size of the blade, so that it can react on a larger body of water, and by increasing the length of the oar, both inboard and outboard, in order to diminish the obliquity at the ends of the stroke. This theoretical possibility is hampered by practical considerations until boat builders condescend to turn their attention to making an improvement on present wooden oars and solid outriggers.

In experiments so far described, the only advances made by the new indicator over the first one have been the greater facility in reducing the results and the possibility of obtaining a mean result from several strokes. Experiments will now be considered for which the continuous record was necessary. These have reference to the effect of fatigue on rowing. Fig. 10 indicates in various ways the growth of fatigue during a continuous piece of rowing. In *A*, ordinates represent the work done during a stroke, whose number from the start is represented by the abscissa. As is to be expected, the strokes vary irregularly, but the steady decrease during the 150 strokes represented is quite clear. *B* represents in the same way the falling off in the maximum pull, and gives a curve almost identical with *A*. *C* shows the change in the stroke form during the interval of some 130 strokes or 6 minutes' rowing.

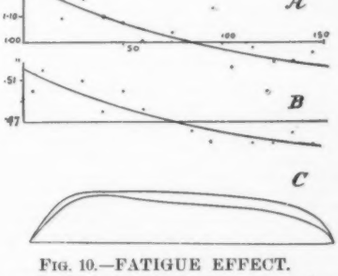



FIG. 10.—FATIGUE EFFECT.
*A*, work; *B*, greatest pull; *C*, change in form.

It will be noticed that the falling off is most marked during the latter half of the stroke, when the legs and arms take a large share in the work. This suggests that while the powerful system of muscles in the shoulders and back does not easily tire, the legs and arms are comparatively weak.

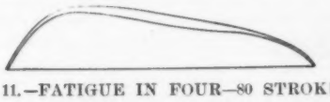


FIG. 11.—FATIGUE IN FOUR—80 STROKES.

Fig. 11 represents the change in stroke-form in a four

* With reference to stroke rate, it is worthy of note that the usual custom of counting strokes, in which the number of strokes in the water is taken, makes an error of more than half a stroke, by omitting one swing forward. Thus if strokes are counted for ¼ min., the deduced rate is too high by 2 per minute.

* It is clearly the projection of the "Instantaneous Center Locus" on the oar.

* The mean position is found to be 36 inches above the tip, a result coinciding with the rough determination with the float eighteen months previously.

† *C* unfortunately was not the oarsman who was rowing in the oar experiment, but, for a general result, this is of no very great moment.

during an interval of 80 strokes. The fatigue curves in this case are steeper than in the last case, but less regular.

Fig. 12 relates to a journey in a Torpid Eight. This was broken up into about 4 pieces by easies, but again the gradual diminution of power is clear. *C* is an analysis on a larger scale of strokes 210 to 310 during

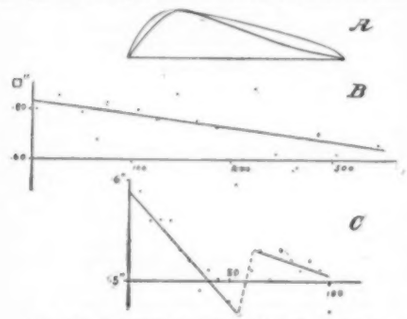



FIG. 12.—FATIGUE IN TORPID EIGHT.
*A* and *B*, 350 strokes; *C*, 100 strokes.

this journey showing the effect of an "easy." The diagram shows the maximum pull, and between the two black lines there is clearly a break in which the oarsman has partly recovered his vigor.

With regard to the magnitude of the fatigue effect, in the first case the fall was 18 per cent. in 6 minutes' continuous rowing, 150 strokes; second, 13 per cent. in 100 strokes; third, 22 per cent. in 350 strokes (intermittent). These and other results show that, even in cases where no extreme exertion is called for, fatigue manifests itself, not only as a sensation, but also in diminished output, and it can easily be imagined how much larger must be the fall in a hard race.

A rough experiment was made to test the use of the indicator for determining the relation between horse power and the resulting velocity of the boat. A pair was rowed between two points, both up and down stream, in order to eliminate the stream velocity. The time and number of strokes was carefully noted. This was carried out once with very little exertion and again working hard. The measurement of the diagrams

FIG. 13.—DIMENSIONS OF OAR.

combined with the other observations gave the H. P. corresponding to a certain relative velocity. Assuming H. P. $\propto$ (Vel.)$^x$, $x$ was found by this experiment to be 2·5—a result probably too low.* For the experiment to have a scientific value it would be necessary to indicate both rowers.

The experiment is alluded to as suggesting the possibility of an investigation that might lead to useful results, and although the author has given a description of some experiments which he hopes may be of some interest to the rowing man and also to the physiologist, yet he feels that at every point more extended and often more careful experiments, for which he has now no longer the opportunity, would be of interest and importance to science.

Temple Observatory, Rugby.

## THE PROTECTION OF STEAM-HEATED SURFACES.†

By C. L. NORTON, Boston, Mass.

THE first object sought for was the relative efficiency of several kinds of steam pipe covering now upon the market. The second object was to ascertain the fire risk attendant upon the use of certain methods and materials used for insulation of steam pipes. Third, an attempt was made to show the gain in economy attendant upon the increase of thickness of coverings, and to show also the exact financial return which may be expected from a given outlay for covering steam pipes.

### METHOD.

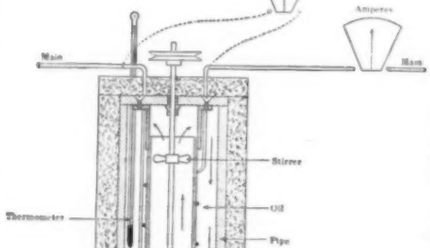
The method adopted is one which, so far as I know, is original. A piece of steam pipe is heated from the inside electrically. The amount of electrical energy supplied is measured, and hence the amount of heat furnished is known. If the steam pipe is kept at a constant temperature by a given amount of heat, it is because that amount is just equal to the heat it is losing, for if the supply were not equal to the loss, the temperature would rise or fall. In other words, the heat put into the pipe is just equal to the heat lost from it by radiation, convection, and conduction. By measuring the electrical energy supplied, I can determine the heat put in, and hence the heat given out or lost. It must be borne in mind that a given amount of electrical energy always produces the same definite amount of heat, the amount of heat furnished by one electrical unit of energy being known with greater accuracy than the amount of heat given out by a pound of steam in condensing.

### APPARATUS.

The apparatus for making tests by this method comprises several pieces of steam pipe of different diameters and lengths, heated electrically from within by means of coils of wire in oil. The oil is stirred vigorously and serves as a very efficient carrier of heat from the wires to the pipes. A brief description of the smallest tester may make the details of the apparatus more easily understood.

A section is shown in the engraving.

A piece of 4-inch steam pipe, 18 inches long, is closed at one end by a plate welded in and at the other by a tightly fitting cover. This pipe is then filled with cylinder oil, and a coil of wire of sufficient carrying capacity and a stirrer are introduced into the oil. A thermometer is inserted in such a position as to record the temperature of the oil. An ammeter and voltmeter or a wattmeter may then be connected so as to record the amount of electrical energy supplied. The stirring must be brisk, and if enough power is put into the stirrer to be comparable with the electrical energy supplied, such amount must, of course, be added, as it also is converted into heat. It is my custom to suspend the apparatus in the middle of the room on non-conducting cords and read the thermometer with a telescope, so that no heat from the person of the observer may be added to the supply given to the cover from within, and also that care may be taken not to




THE PROTECTION OF STEAM-HEATED SURFACES.

produce air currents by walking near the apparatus during the test.

### PROCEDURE.

In making a test the following operations are carried out, and observations are taken in the following order: The current is turned on, and heat is generated in the wire coil until the wire, oil and steam pipe have reached the desired temperature at which it is proposed to test. The current is then gradually diminished until it is found to be of just the amount necessary to keep the pipe at this temperature without a rise or fall of 1·10° in 30 minutes. A reading of the voltage and current is now taken at intervals of 30 seconds, and the watts and B. T. U. are computed from their average. We then have the number of B. T. U. lost from the outside of this particular pipe at this particular temperature. If now we place a steam pipe cover around the pipe, we shall find that a less amount of energy is sufficient to keep it at the required temperature, the difference being the amount of heat saved by the covering. The minimum length of time considered sufficient for the equalization of heat or soaking in to the cover is six hours. If after a second heating of six hours no change in the conducting power is noted, the cover is considered in a permanent condition and is tested. Some covers, notably those composed wholly or in part of wool, cannot be considered dry and constant until after an exposure upon a pipe at 200 pounds pressure for six or eight days. Covers containing sulphate of lime are also slow in drying.

The three thermometers used were frequently standardized in naphthaline, and were examined to note any disagreement among themselves.

A discussion of the position of the tester and its exposure to air currents will be found in a later paragraph.

### RESULTS.

A comparative test was made in 1895, upon a number of steam pipe covers on a 4-inch tester 16 inches long. The results obtained have been published in the circulars issued by the Boston Manufacturers' Mutual Fire Insurance Company and by the Steam Users' Association. The values were stated to be purely relative, the specimen being too small to give reliable data on the absolute conduction, and the surrounding conditions not being controlled other than to maintain them constant during the several runs. The ends of the specimen were covered by massive heads, and the whole tester was situated within a few inches of a brick wall and a stone pier. It was called to my attention that the heat loss was probably high, and I agree that the exposure was such as to make it so, being a rather harsh test, but one which was rigidly uniform in its requirements of the several covers. In short the actual loss of heat per square foot of the pipe surface was correct for that particular piece under the conditions of the test, but was not sufficient for the estimation of the actual saving which might be expected from the general use of coverings. I deemed it wise, therefore, to construct new heaters, 4 and 10 inches in diameter and 36 inches long. These were suspended by non-conducting cords in the center of the laboratory, so as to hang freely and not be in contact with any conducting supports. Conduction up the lead wires and stirring rod was found to be negligible.

It seems to me that I have approached more nearly the conditions of actual practice than can be obtained by any other method of testing, except the actual use of a long run of pipe; and the determination of the amount of heat put into such a pipe by the condensation method offers many difficulties and is open to much uncertainty. I feel, therefore, that in adopting this method I am using a reasonable exposure for the pipe, and have an exceptionally good opportunity to measure the heat supplied.

Table I. gives the relative conductivity of the various kinds of steam pipe cover tested up to April, 1898. It gives the results of the tests upon most of the samples tested, some being omitted when found to be of such low efficiency as to be of doubtful value.

TABLE I.

| Specimen. | Name. | B. T. U. loss per square foot of pipe surface per minute. | Ratio of loss to loss from bare pipe. | Thickness in inches. | Weight in ounces per foot of length, 4 inches diameter. |
|---|---|---|---|---|---|
| A | Nonpareil cork standard | 2·20 | 15·9 | 1 00 | 27 |
| B | Nonpareil cork octagonal | 2·38 | 17·2 | 0·80 | 16 |
| C | Manville high pressure | 2·26 | 17·2 | 1·25 | 54 |
| D | Magnesia | 2·45 | 17·7 | 1 12 | 35 |
| E | Imperial asbestos | 2·49 | 18·0 | 1 12 | 45 |
| F | W. B | 2·62 | 18·9 | 1·12 | 59 |
| G | Asbestos air cell | 2·77 | 20·0 | 1 12 | 35 |
| H | Manville infusorial earth | 2·80 | 20·2 | 1 50 | ..... |
| I | Manville low pressure | 2·87 | 20·7 | 1 25 | ..... |
| J | Manville magnesia asbestos | 2·88 | 20·8 | 1·50 | 65 |
| K | Magnabestos | 2·91 | 21·0 | 1·12 | 48 |
| L | Moulded sectional | 3·00 | 21·7 | 1·12 | 41 |
| M | Marsden infusorial earth | 3·11 | 22·5 | 1 00 | 50 |
| N | Marsden infusorial earth | 3·27 | 23·7 | 1·00 | 43 |
| O | Asbestos fire board | 3·33 | 24·1 | 1 12 | 85 |
| P | Calcite | 3·61 | 26·1 | 1 12 | 66 |
| | Bare pipe | 13·84 | 100·0 | ... | ..... |

Specimen A consists of granulated cork pressed in a mould at high temperature and then submitted to a fireproofing process.

Specimen B is similar in composition, but is made up of several strips of cork instead of two semicylindrical sections.

Specimen C is a sectional cover composed of an inner jacket of earthy material and an outer jacket of wool felt, the whole being 1¼ inches thick.

Specimen D is a moulded sectional cover composed of about 90 per cent. carbonate of magnesia.

Specimen E is essentially an air cell cover, being composed of sheets of asbestos paper which has been indented before being laid up, the indentations serving to keep the thin sheets of paper from coming in close contact with one another, thereby causing a considerable amount of air to be held throughout the body of the cover.

Specimen F is composed of a wool felt with a lining of asbestos paper.

Specimen G is a cover made up of thin sheets of asbestos paper fluted or corrugated and stuck together with silicate of soda.

Specimen H is a plastic covering made of infusorial earth.

Specimen I is a low pressure covering similar to Specimen F.

Specimen J is a plastic cover, and called by the makers magnesia asbestos. It contains only a slight amount of carbonate of magnesia.

Specimen K, the magnabestos, is a moulded cover, containing about 45 per cent. of carbonate of magnesia and a considerable percentage of carbonate of lime.

Specimen L is composed mainly of sulphate of lime and some 20 per cent. of carbonate of magnesia and has upon its outer surface a thick sheet of felt board.

Specimen M is a sectional moulded cover. It is composed largely of infusorial earth from California.

Specimen N is similar to Specimen M, except that to its composition has been added some 45 per cent. of carbonate of magnesia.

Specimen O is similar to Specimen G, except that it has larger cells and contains much more silicate of soda. It is very hard and strong.

Specimen P is a sectional moulded cover, composed mainly of sulphate of calcium. It has an outer layer of felt board.

Table III. gives the saving, in dollars, due to the use of the various covers.

TABLE III.

| Specimen. | Name. | Loss B. T. U., 200 Pounds. | Saving, B. T. U. | Saving per Year per 100 Square Feet. |
|---|---|---|---|---|
| A | Nonpareil cork standard | 2·20 | 11·64 | $37.80 |
| B | Nonpareil cork octagonal | 2·38 | 11·46 | 37.20 |
| C | Manville sectional, H. P. | 2·26 | 11·46 | 37.20 |
| D | Magnesia | 2·45 | 11·30 | 36.90 |
| E | Imperial asbestos | 2·49 | 11·35 | 36.80 |
| F | W. B | 2·62 | 11·22 | 36.40 |
| G | Asbestos air cell | 2·77 | 11·07 | 35.00 |
| H | Manville infusorial earth | 2·80 | 11·04 | 35.85 |
| I | Manville low pressure | 2·87 | 10·97 | 35.65 |
| J | Manville magnesia asbestos | 2·88 | 10·96 | 35.60 |
| K | Magnabestos | 2·91 | 10·93 | 35.50 |
| L | Moulded sectional | 3·00 | 10·84 | 35.20 |
| M | Marsden No. 2 | 3·11 | 10·73 | 34.85 |
| N | Marsden No. 1 | 3·27 | 10·57 | 34.60 |
| O | Asbestos fire board | 3·33 | 10·51 | 34.20 |
| P | Calcite | 3·61 | 10·23 | 33.24 |
| | Bare pipe | 13·84 | 0 00 | ..... |

* RESISTANCE AND HORSE POWER AS A FUNCTION OF VELOCITY.

In the experiment referred to in the article, the H. P.'s in the two cases were 0·294 and 0·151 respectively, while the velocities were in ratio 421 to 321.

$$\text{If H. P.} = k\,(Vel)^x \quad x = \frac{\log 294 - \log 151}{\log 421 - \log 321} = 2·5$$

Comparing this with examples of towing vessels, this would appear rather low.

There is, however, a difference between towing and propelling with internal mechanism.

In former case, if Resistance $= k\,V^2$ where $V$ = velocity,
Horse power $= kV^2 \times V = kV^{2+1}$.

In the latter case, in which the vessel is propelled, for example, with a screw or oar, the force of propulsion is obtained by generating momentum in the water. Making the apparently legitimate assumption that the mass of water encountered by the propeller varies as the velocity of the vessel (probably more correct in the case of the screw than with an oar), since the rate at which the propeller is passing the main body of water is $V$,

If Resistance $= kV^2$, again

H. P. $= lV^2 + 1 + mV^2 - 1$ where $l$ and $m$ are constants.

So that unless $x = 2$, the H. P. required no longer varies as $V^{2+1}$.

I have nowhere seen this pointed out, and should be glad of any information on the subject.

† Abstract of paper presented at the Niagara Falls meeting of the American Society of Mechanical Engineers.

Table IV. shows that at the end of ten years the best of the covers tested will have saved $46 more than the poorest. The difference between the several covers of the better grade is exceedingly small.

TABLE IV.—NET SAVING PER 100 SQUARE FEET.

| Specimen. | Name. | 1 Year. | 2 Years. | 5 Years. | 10 Years. |
|---|---|---|---|---|---|
| A | Nonpareil cork standard | $12.80 | $50.60 | $164.00 | $353.00 |
| B | Nonpareil cork octagonal | 12.30 | 49.40 | 161.00 | 347.00 |
| C | Manville sectional high pressure | 12.30 | 49.40 | 161.00 | 347.00 |
| D | Magnesia | 11.90 | 48.80 | 159.50 | 344.00 |
| E | Imperial asbestos | 11.80 | 48.60 | 159.00 | 343.00 |
| F | W. B. | 11.30 | 47.80 | 157.00 | 339.00 |
| G | Asbestos air cell | 11.00 | 47.00 | 155.00 | 335.00 |
| H | Manville infusorial earth | 10.85 | 46.70 | 154.25 | 333.00 |
| I | Manville low pressure | 10.65 | 46.30 | 153.75 | 331.00 |
| J | Manville magnesia asbestos | 10.60 | 46.30 | 153.00 | 331.00 |
| K | Magnabestos | 10.50 | 46.00 | 152.50 | 330.00 |
| L | Watson's moulded sectional | 10.30 | 45.40 | 151.00 | 327.00 |
| M | Marsden No. 2 | 9.85 | 44.70 | 149.20 | 323.00 |
| N | Marsden No. 1 | 9.60 | 44.20 | 148.00 | 321.00 |
| O | Asbestos fire board | 9.20 | 43.40 | 146.00 | 317.00 |
| P | Calcite | 8.24 | 41.48 | 141.20 | 307.00 |
| Q | Bare pipe | | | | |

The money saving is computed on the following assumptions: Coal at $4 a ton evaporates 10 pounds of water per 1 pound of coal. The pipes are kept hot ten hours a day 310 days a year. If computations are made, as is sometimes done, on an assumption that the pipes are hot 24 hours a day 365 days in a year, the saving is nearly three times that shown in Table III.

Generally speaking, a cover saves heat enough to pay for itself in a little less than a year, at 310 ten-hour days, and in about four months at 365 twenty-four-hour days.

## STATISTICS OF THE RAILWAYS OF THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1897.

FROM summaries which will appear in the Tenth Statistical Report of the Interstate Commerce Commission, prepared by its statistician, being the complete report for the above-named period, for which a preliminary income account was issued in December, 1897, the following advance figures are obtained:

On June 30, 1897, there were 128 roads in the hands of receivers. These roads operated a mileage of 17,861·68 miles, the mileage owned by them being 14,894·57 miles. These figures, as compared with those for 1896, show that there was a net decrease of 12,613·71 miles in mileage operated, and 8,622·89 miles in mileage owned by roads in the charge of receivers. During the year ending June 30, 1897, 51 roads were removed from the control of receivers and 28 roads were placed under their management. An inspection of the roads operated under receiverships on June 30, 1897, shows that 22 operated a mileage in excess of 500 miles, 20 between 100 and 300 miles, and 70 a mileage less than 100 miles. It is not always possible to secure complete returns for railways operated by receivers, but the following figures may be accepted as practically correct with respect to railways of this class: The capital stock represented by these railways on June 30, 1897, was $486,064,610; funded debt, $531,407,790; and current liabilities, $113,806,348. A comparison of these figures with those corresponding for the preceding year shows a decrease in capital stock represented of over $256,000,000 and in funded debt of over $468,000,000.

### MILEAGE.

The total railway mileage in the United States on June 30, 1897, was 184,428·47 miles, there being an increase of 1,651·84 miles, or 0·90 per cent. during the year. In round numbers, Alabama shows an increase of 117 miles; Arkansas, 192 miles; California, 219 miles; Louisiana, 161 miles; and Michigan, 123 miles. The increase in mileage in the other States and Territories in which an increase occurred was less than 100 miles. In a few States, as usual, a decrease in mileage is shown. The aggregate length of railway mileage, including all tracks, on June 30, 1897, was 243,444·41, the increase being 3,315·29 miles. The length of second track was 11,018·47 miles; of third track, 995·79 miles; of fourth track, 780·48 miles. The mileage of yard track and sidings amounted to 46,221·20 miles.

Excepting yard track and sidings, about 32 per cent. of which are laid with iron rails, substantially 95 per cent. of the railway tracks in the country are laid with steel rails.

### CLASSIFICATION OF RAILWAYS.

The number of railway corporations on June 30, 1897, embraced in the "Statistics of Railways in the United States" was 1,987. Of this number 1,037 maintained operating accounts, 819 being classed as independent operating roads, and 218 as subsidiary operating roads. Of the roads operated under lease or other agreement, 320 received a fixed money rental and 169 a contingent money rental; 258 were assigned for operation under forms of agreement not easily classifiable.

The operated mileage affected by reorganization and other corporate changes during the year ending June 30, 1897, was 14,942·39 miles, of which 13,230·57 miles pertained to reorganized roads.

### EQUIPMENT.

The total number of locomotives in service on June 30, 1897, was 35,986, the increase in number as compared with the preceding year being 36. Of the total number of locomotives reported, 10,017 were classed as passenger locomotives, 20,398 as freight locomotives, and 5,102 as switching locomotives. The number of locomotives not classified was 469. The total number of cars of all classes reported in service on the date named was 1,297,480. The corresponding number for the previous year was 169 greater. Of the total cars reported, 33,626, or 623 more than for 1896, were assigned to the passenger service; 1,221,730 were assigned to freight service, indicating a decrease of 157 during the year; and 42,124 were assigned to the special service of the railway companies. As has been stated in former years, the Division of Statistics has no record of the number of cars owned by private companies and individuals that are used by railways in transportation service.

From summaries which indicate the density of equipment and its efficiency in the transportation of passengers and freight, it is observed that during the year ending June 30, 1897, the railways in the United States used 20 locomotives and 7·8 cars per 100 miles of line. Taking the United States as a whole, it appears that 48,861 passengers were carried and 1,223,614 passenger-miles accomplished per passenger locomotive, and correspondingly there were 36,362 tons carried and 4,664,135 ton-miles accomplished per freight locomotive. All of these items show a decrease as compared with those of the preceding year. The number of passenger cars per 1,000,000 passengers carried during the year under consideration was 69, and the number of freight cars per 1,000,000 tons of freight carried was 1,647. It should be understood, however, that this average does not include such cars, mainly in the freight service, as are owned by private parties, for the use of which the railways paid during the year approximately $11,000,000. Including in the term equipment both locomotives and cars, it is found that the total equipment of railways on June 30, 1897, was 1,333,466. These figures are 133 less than on June 30, 1896. Of this total number 525,286 were fitted with train brakes, the increase being 76,432; and 678,725 were fitted with automatic couplers, the increase in this case being 133,142. These increases are somewhat smaller than the corresponding increases for 1896. It should be noted, however, that the number representing the increase in equipment in that year was over 27,000. Further details as to equipment on June 30, 1897, show that the number of passenger locomotives fitted with train brakes were 9,899, or 83 more than the preceding year. The number of freight locomotives so fitted was 18,796, or 875 more than the preceding year. The number of switching locomotives fitted with train brakes was 3,666. The number of passenger locomotives fitted with automatic couplers was 4,087, the increase with respect to 1896 being 184. The number of freight locomotives fitted with automatic couplers was 4,192, the increase being 819. The number of switching locomotives fitted with such couplers was 741, or 147 more than for 1896. The number of passenger cars fitted with train brakes on June 30, 1897, was 33,078, and the number fitted with automatic couplers was 32,061, the increase in the one case being 665 and in the other 815. The number of cars in freight service fitted with train brakes was 453,688, or 74,630 more than on June 30 of the previous year. The number fitted with automatic couplers was 629,399, indicating an increase of 129,166. Of the total cars in service, 492,559 on June 30, 1897, were fitted with train brakes, and 668,937 were fitted with automatic couplers, the increase for the year in the former case being 75,237; in the latter, 131,989.

### EMPLOYES.

The number of men employed by the railways of the United States on June 30, 1897, as reported, was 823,476. These figures, assigned on the mileage basis, show that 449 men were employed per 100 miles of line. The corresponding figures for the year ending June 30, 1896, were slightly larger. The employes of railways are divided into 18 classes. The number of station agents as reported for the date named was 30,049; other station men, 74,569; enginemen, 35,667; firemen, 36,735; conductors, 25,322; other trainmen, 63,673; switchmen, flagmen, and watchmen, 43,768; and telegraph operators and dispatchers, 21,452. A distribution of employes corresponding to the four principal divisions of the classification of operating expenses shows that general administration required the service of 31,871 employes, or 17 per 100 miles of line; maintenance of way and structures, 244,873, or 134 per 100 miles of line; maintenance of equipment, 160,667, or 88 per 100 miles of line; and conducting transportation, 378,361, or 206 per 100 miles of line. This statement disregards a small number of unclassified employes amounting to 7,704.

A comparative summary is presented in the report of the average daily compensation of the different classes of employes for the years 1892 to 1897. Another summary is given in the report which shows the total amount of compensation reported as paid to railway employes during the fiscal years 1895 to 1897. It covers the compensation of over 99 per cent. of railway employes for the several years. Regarding the year ending June 30, 1897, it appears that the aggregate amount of wages and salaries paid was $465,601,581. This amount represents 61·87 per cent. of the total operating expenses of railways, or $2·540 per mile of line. The total compensation for 1896 was $3,222,950 greater.

### CAPITALIZATION AND VALUATION OF RAILWAY PROPERTY.

On June 30, 1897, the amount of railway capital outstanding was $10,635,008,074, which, assigned on a mileage basis, shows a capital of $59,620 per mile of line. The amount of capital stock was $5,304,642,255, of which $4,367,056,657 was common stock and $937,585,598 preferred stock. The amount of funded debt was $5,270,365,819. The classification of funded debt shows that it consists of mortgage bonds, $4,539,911,595; miscellaneous obligations, $430,718,303; income bonds, $259,847,154, and equipment trust obligations, $39,888,767. The amount of capital stock paying no dividend was $3,761,092,277, or 70·10 per cent. of the total amount outstanding. The amount of funded debt, excluding equipment trust obligations, which paid no interest was $867,950,840. Of the stock paying dividends, 5·37 per cent. of the total stock outstanding paid from 1 to 4 per cent; 6·53 per cent. outstanding paid from 4 to 5 per cent., 5·99 per cent. outstanding from 5 to 6 per cent., 3·58 per cent. outstanding from 6 to 7 per cent., and 4·62 per cent. outstanding from 7 to 8 per cent. The total amount of dividends was $87,110,599, which would be produced by an average rate of 5·43 per cent. on the amount of stock on which some dividend was declared. The amount of mortgage bonds paying no interest was $615,259,989, or 13·55 per cent; of miscellaneous obligations, $37,345,879, or 8·67 per cent.; and income bonds, $215,344,972, or 82·87 per cent. The amount of current liabilities outstanding on June 30, 1897, was $578,501,635, or $3,156 per mile of line.

### PUBLIC SERVICE OF RAILWAYS.

The number of passengers carried during the year ending June 30, 1897, as reported, was 489,445,198, there being a decrease of 22,327,539 as compared with the year ending June 30, 1896. The number of passengers carried 1 mile during the year was 12,256,939,647, a decrease of 792,067,586 being shown in this item as compared with 1896. The number of passengers carried 1 mile per mile of line—that is, the average indicating the density of passenger traffic during the year ending June 30, 1897—was 66,874, a decrease of 4,831 in this item being shown. The number of tons of freight carried during the year was 741,705,946, which is 24,185,439 less than for 1896. The number of tons of freight carried 1 mile was 95,139,022,225. This item also was less than for 1896, the decrease being 189,338,053. As in the case of passenger traffic, the density of freight traffic is shown by the number of tons of freight carried 1 mile per mile of line, which was 519,079. This amount is 4,753 less than the similar item for the preceding year.

### EARNINGS AND EXPENSES.

The gross earnings of the railways of the United States for the year ending June 30, 1897, as reported for an operated mileage of 183,284·25, were $1,122,089,773. In comparison with the preceding year this amount shows a decrease in gross earnings of $28,079,693. The sources of income comprised in gross earnings from operation for the year were: Passenger revenue $251,135,927, decrease as compared with the previous year $15,426,606; mail $33,754,466, increase $1,374,647; express $24,901,066, increase $20,683; other earnings, passenger service $6,629,980, freight revenue $772,849,314, decrease $13,766,523. Other earnings, freight service $4,209,657, increase $323,767. Other earnings from operation, including a small amount of unclassified items, $28,609,363. The expenses of the operation of railways for the fiscal year covered by the report were $752,524,764. This amount is $20,464,280 smaller than the corresponding amount for the year ending June 30, 1896, the operated mileage for that year being 181,982·64 miles.

The operating expenses of 1897 were distributed as follows: Maintenance of way and structures, $159,434,403, decrease as compared with the preceding year, $910,547; maintenance of equipment, $122,762,358, decrease, $10,619,640; conducting transportation, $432,525,862, decrease, $9,691,720; general expenses, $36,481,269, increase, $397,984. Gross earnings per mile of line operated averaged $6,122; operating expenses, $4,106. These amounts are, respectively, $198 and $142 less than the averages for 1896. A comparative summary appears in the report which gives an analysis of the operating expenses of the railways in the United States for the years 1895 to 1897, following the prescribed classification of operating expenses, which embraces 53 items.

The income from operation, that is, the amount of gross earnings remaining after the deduction of operating expenses, commonly termed net earnings, was $369,565,009. This amount is $7,615,323 less than the corresponding item for the previous year. The income from other sources, mainly derived from leases and investments in stocks and bonds, was $125,090,010, which, added to the income from operation, shows that the total income of the railways as a whole was $494,655,019. The corresponding amount for the year ending June 30, 1896, was $506,205,063. The total deductions from income were $413,397,513. Taking this amount from total income leaves $81,257,506 as the net income for the year available for dividends or increase of surplus. The total amount of dividends declared, including $267,390 other payments from net income, was $87,377,989, the result being a deficit from the operations of the year of $6,120,483. An analysis of the total deductions from income stated above, $413,397,513, shows the following classification: Salaries and maintenance of organization, $508,598; interest on funded debt, $247,880,230; interest on interest-bearing current liabilities, $7,844,336; rents paid for lease of road, $87,505,302; taxes, $43,137,844; permanent improvements, $4,544,813; other deductions, $21,976,390. These figures should be understood as covering lines operated under lease or other agreement as well as operating companies.

### RAILWAY ACCIDENTS.

The total number of casualties to persons on account of railway accidents for the year ending June 30, 1897, was 43,168. Of these casualties 6,437 resulted in death, and 36,731 in injuries of varying character. Of railway employes, 1,693 were killed and 27,667 were injured during the year. According to the three general classes these casualties were divided as follows: Trainmen, 976 killed, 13,795 injured; switchmen, flagmen, and watchmen, 201 killed, 2,423 injured; other employes, 516 killed, 11,449 injured. The casualties to employes resulting from coupling and uncoupling cars were, killed, 214; injured, 6,283. The corresponding figures for the year ending June 30, 1896, were 229 killed and 8,457 injured. The casualties from coupling and uncoupling cars were assigned as follows: Trainmen, killed, 147, injured, 4,698; switchmen, flagmen, and watchmen, killed, 58, injured, 1,325; other employes, killed, 9, injured, 260. The casualties resulting from falling from trains and engines were as follows: Trainmen, killed, 325, injured, 2,726; switchmen, flagmen and watchmen, killed, 32, injured, 357; other employes, killed, 51, injured, 544.

The casualties to the three general classes of employes mentioned caused by collisions and derailments were as follows: Trainmen, killed, 250; injured, 1,327; switchmen, flagmen, and watchmen, killed, 11; injured, 74; other employes, killed, 42; injured, 251. The total number of passengers killed during the year under review was 222, injured, 2,795. Ninety-three passengers were killed and 1,011 injured in consequence of collisions and derailments. Other than employes and passengers the total number of persons killed was 4,522; injured, 6,269. Included in these figures are casualties to persons classed as trespassers, of whom 3,919 were killed and 4,732 were injured. From summaries showing the ratio of casualties, it appears that 1 out of every 486 employes was killed and 1 out of every 30 employes was injured during the year. With respect to trainmen, including enginemen, firemen, conductors, and other trainmen, it appears that 1 was killed for every 165 employed, and 1 injured for every 12 employed. One passenger was killed for every 2,204,708 carried, and 1 injured for every 175,115 carried. Basing ratios upon the number of miles traveled, it appears that 55,211,440 passenger-miles were accomplished for each passenger killed, and 4,385,309 passenger-miles for each passenger injured.

## THE SARDINE FISHERY.

SARDINE fishing in France begins at the time of spawning, say along about the first of June. As soon as the fishermen of the coast of Brittany perceive numerous herds of porpoises to the seaward, or, better yet, large numbers of gulls diving at very close intervals, they fit out their boats, since the fish have arrived.

The boats, of which the construction near the fisheries occupies a large number of workmen during the dull season, generally gage a dozen tons, and are manned by from six to ten persons. The skipper and his mate alone are professional fishermen, the others belonging to the great family of manual laborers, farmers, vinedressers, etc.

The fishing apparatus consists solely of close meshed nets of a length varying from 300 to 1,500 feet. These are supported at the surface of the ocean by corks, and kept taut at the lower part by lead weights. In order to render it less conspicuous, the net is dyed sea water color.

When the first schools of fish are sighted off land, the sails are hoisted and the boats make for the fishing ground.

The exact presence of the fish is shown by a layer of oily substance that floats upon the surface, and also by a considerable quantity of small scales, which, being held in suspension in the water, give it a metallic aspect.

At the moment that the skipper has brought his boat over the school, he drops his sails, and two of the crew, provided with oars, pull gently in each direction, so as to keep the boat practically in one place, while the others cast the net. Standing in the stern, the skipper then throws out the "rogue" by the handful. The "rogue" is a bait composed of codfish roes designed to keep the fish on the spot. In a few moments, if the fishes are plentiful, new quantities of scales float upon the surface, and the net itself is agitated in each direction with quick motions. The net is then hauled in, while the sails are again hoisted, the boat heads for the nearest port, and the men shake out upon the deck all the fish that have been entangled in the meshes.

One quite peculiar thing that the method of fishing can alone explain is that it is rare to see a living sardine come from the water, and that, when such an event does occur, it dies almost instantly in uttering a little cry.

Out of the two hundred and fifty or three hundred fishing boats fitted out during the season at Belle-Isle, two hundred belong to the port of Palais and the rest to that of Sauzon.

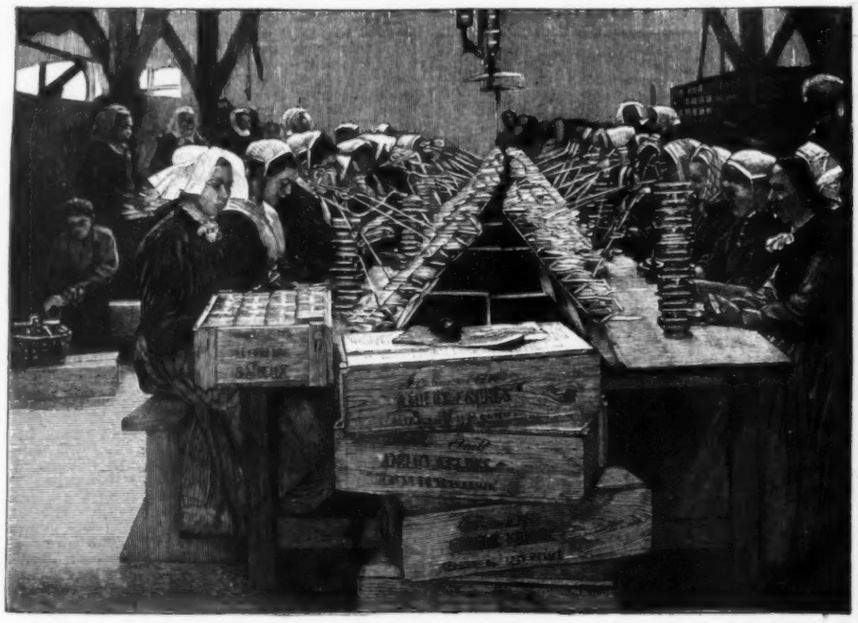
It is likewise at these two ports that the purchase of the sardines is negotiated. As the outcome of quite an ordinary catch gives for each boat an average of eight or ten thousand fish, the market is established upon the quantity brought in by the first arrivals. Here, upon the moles, the representatives of the large canning houses wait and make their purchases. This business having been finished, the sardines are counted by basketfuls of two hundred and immediately carried by the fishermen to the works. The Messrs. Amieux, says L'Illustration (from which we borrow these details and the accompanying engravings), having put one of their eleven establishments, that of Sauzon, at our disposal for a study of the different phases of the preparation of the sardine, it is to this large establishment that we shall take the reader.

Situated at the edge of the ocean and at the back of a charming natural port into which the fishing boats can easily enter, the buildings dominate the coast and have as a near neighbor, to the west, only Mme. Sarah Bernhardt's fort.

In the fishing season, about three hundred women and fifty men are permanently employed at the works, and await with a certain amount of anxiety the arrival of the first boats. The female employes, in their picturesque Breton costumes, take their station in the first preparation hall. Here the fish, having been spread out upon tables, are first slightly salted, and then the force proceeds to do the cleaning, which consists in removing the head and entrails. As soon as this operation is finished, boys sort out the fish according to their size and carry them to another part of the works, where they are put into brine. The duration of this treatment depends upon the size of the fish.

As no immediate alteration can now take place, the sardines are washed in a large quantity of water and then very carefully placed, one by one, upon special wire apparatus called grils, and immediately afterward are set aside to dry in the open air. If the weather is rainy or simply foggy, this operation is rendered impossible, and the fish is immediately lost, and is no longer fit for anything except to fertilize the earth.

The house under consideration has remedied this inconvenience by constructing a mechanical drier—a sort of immense fanning machine actuated by a powerful steam engine. The sardines are submitted to a strong current of air for a few moments, and immediately afterward, always resting upon the grils, are immersed in large pans containing boiling olive oil. This operation lasts from three to five minutes, according to the size of the fish. In order that the olive oil necessary for the oiling may preserve its natural taste, the pans are not heated by a naked fire, but by tubes that lead superheated steam through the liquid.

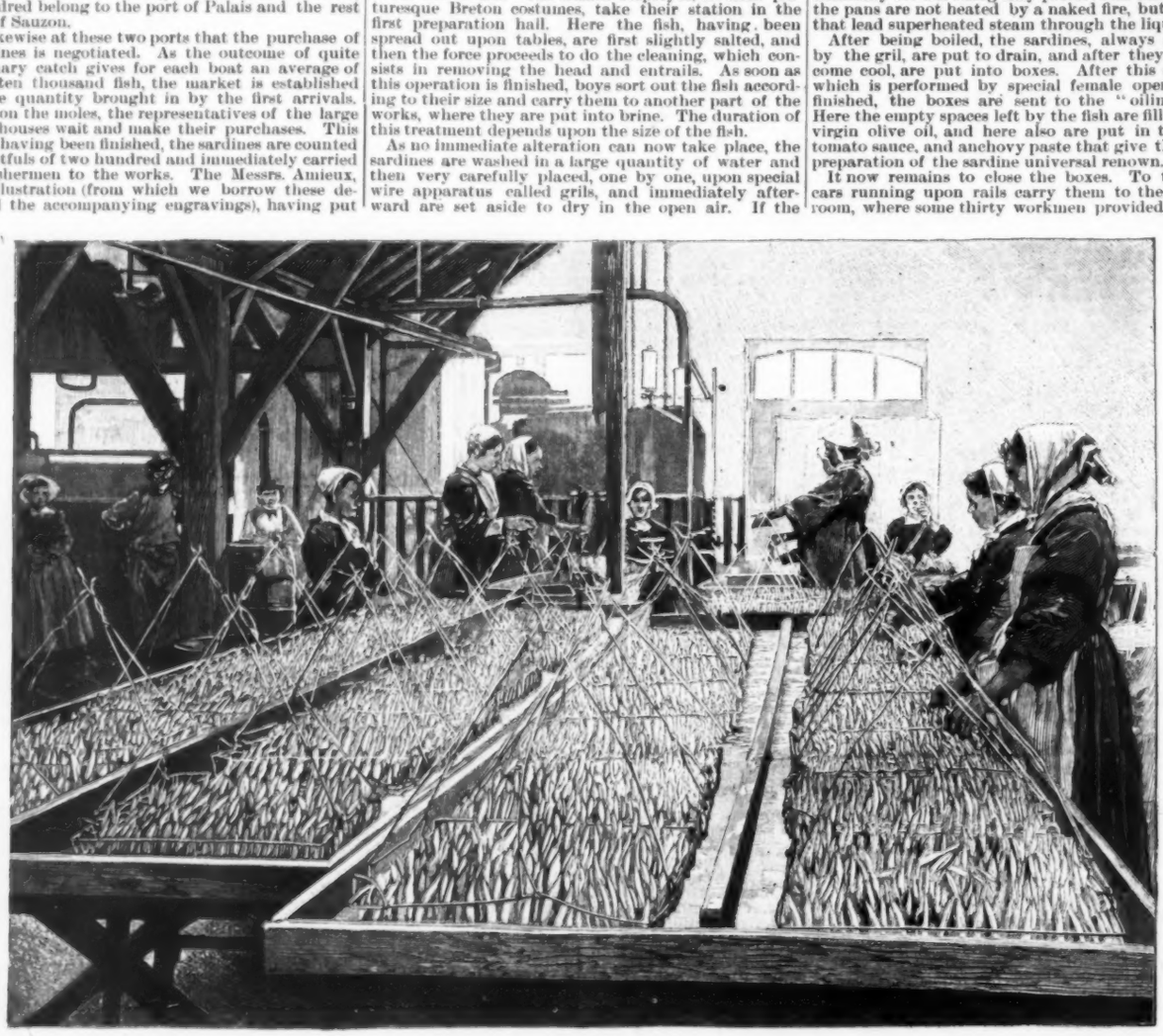


CANNING THE SARDINES.

After being boiled, the sardines, always supported by the gril, are put to drain, and after they have become cool, are put into boxes. After this operation, which is performed by special female operatives, is finished, the boxes are sent to the "oiling" room. Here the empty spaces left by the fish are filled in with virgin olive oil, and here also are put in the spices, tomato sauce, and anchovy paste that give the French preparation of the sardine universal renown.

It now remains to close the boxes. To this effect cars running upon rails carry them to the soldering room, where some thirty workmen provided with soldering irons heated with gasoline fasten the cover to the box.

In order to destroy the microbes that might be inclosed in the boxes, the latter are immersed in large pans of boiling water for a length of time dependent upon their size.



BOILING THE SARDINES IN OIL.

After being removed from the water they are dried in sawdust and then inspected.

The inspecting is done at Sauzon by a Breton, through whose hands passes every box packed in the works.

If a defect in the soldering appears, the box is rejected and thrown into the waste heap as having contents possessing no value as food. When the boxes are found to be perfect they are packed in cases of a hundred, and it is in this form that they are put upon the market.

In an establishment of the size of the one under consideration sardines can be shipped all prepared ten hours after they have been taken out of water.

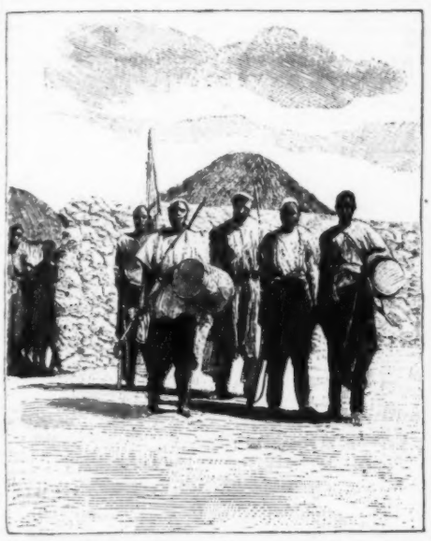
In closing, let us give a word of advice: Never eat sardines newly prepared, since they have neither the odor nor the taste of those that have been boxed for a year.

## GENTIL'S MISSION TO THE TCHAD.

AFTER passing two years in Congo on various missions, maturing his projects and improving his African apprenticeship with a master like M. Brazza, M. Gentil, having returned to France, obtained by force of tenacity the necessary credit to buy a boat to take him to the Tchad with a few companions.

This boat, which was built at Saint Denis, was carried from France in April, 1895, by M. Gentil, who, on November 1, 1896, put it upon the Tchad after eighteen months of incredible labor. It was constructed in parts, so as to render it portable, and was first put together at Brazzaville and floated upon the Congo. M. Gentil started for Oubanghi, with the following companions: M. Fredon, M. Huntzbutler, M. Prins, M. Mostruejouls, a mechanic, and the devoted Ahmed ben Mescham, the brave interpreter of Mizon, who for more than a year guarded the French flag at Yola against the menaces of the English. Upon the Congo, the Oubanghi, and the Kemo the party was in a known country, but navigation and life were not any more easy for all that. At the Kemo began the new business. Upon an affluent of this river, the Tomi, M. Gentil founded the post of Krebedge in 5° 46'. Then it was necessary to pass from the basin of the Congo into that of the Tchad. And here began the navigation of the Leon Blot (as the boat was named) upon land again. Taking into consideration that there are 120 miles of underbrush between the two basins, and that the natives absolutely detest the work of portage and are not very fond of the French, the enterprise of transporting a steamer from the Congo to the Tchad was almost superhuman. But the Leon Blot was finally floated on the first river selected, an affluent of the Chari. At 6° 46' this river is not navigable, and it became necessary to seek another line of navigation. It was not till April, 1897, that M. Gentil was well on his entrance way, in 70° of longitude and 16° of east latitude, upon an affluent of the Gribingui, which is an affluent of the Chari emptying into the Tchad.

The post of Gribingui became his base of operations, and here he left MM. Fredon and Prins, and descended toward the Tchad. Before arriving there, he stopped two months upon the Chari, in front of Massinia, the present residence of the Sultan of Baguirmi. Here he was well received; the sultan tried to dissuade him from going further. As the lake towns

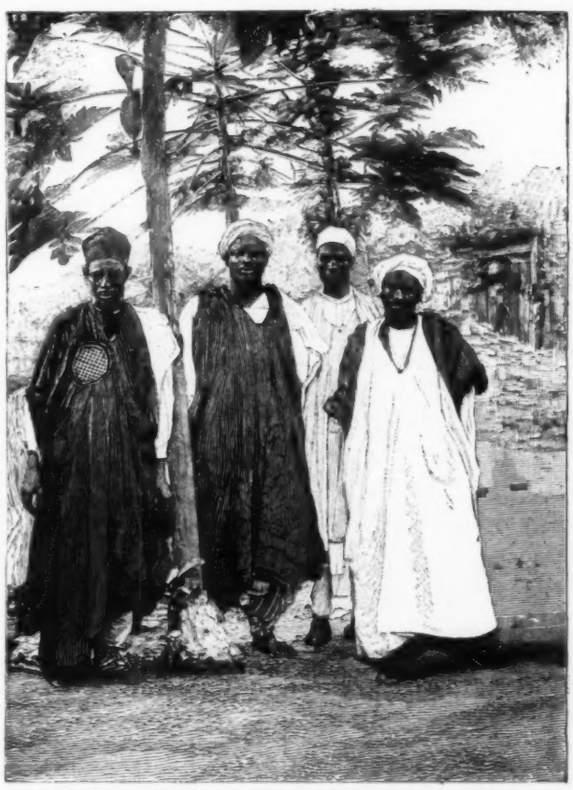


MUSICIAN SOLDIERS OF THE BAGUIRMI.

On the reverse, terrorized by its arrival, the garrisons took refuge at Dikoa. The following is a brief description of Goulfei, which is a fortress situated upon the left bank of the Chari. Its walls, which are about 8,000 feet in length, are further prolonged by forts projecting upon the right. It is inhabited by 10,000 persons of the Koloko race, and has very clean streets. The houses are of beaten earth and covered with thatch.

On its return the party stopped at this place at midday. "A crowd of several thousand persons on their knees," says M. Gentil, "their arms raised, seemed to implore us. All at once a piercing clamor rose from the crowd. It was like a loud complaint, which touched us deeply. We were received with the 'fatrach.'"

As regards the Tchad, we give way again to M. Gentil: "On November 1, the Leon Blot made its entrance into the open waters of the Tchad. I assure you that it was a wonderful spectacle—a true sea, and, to complete the illusion, a fine breeze was blowing that formed quite large billows. Those who deny the existence of this sea would be surprised at it. I must avow that, in order to be able to speak of the Tchad, it is necessary to be able to enter it. Now, being given the inextricable confusion of islands that are found at its entrance, it is impossible to perceive from terra firma anything but grasses, rushes, and papyri, the sole plants of the lake."



THE BAGUIRMI AMBASSADORS.

were in the power of Rabah, the assassin of Crampel, and chief of very powerful armies, the sultan said that it was folly to go with so few men to throw himself into the jaws of the wolf.

M. Gentil pursued his way, however, and, contrary to all expectations, no attack was made upon the party.

And now, in conclusion, a few words as to the political results of the Gentil mission. They are: The making of a connection with Rabah, the sultan, who holds Kouka, the north and the east of the Tchad; a protectorate established upon the Baguirmi, to the south of the Tchad; and the establishment at the Baguirmi of the economic mission of M. de Behagle, agent of the "French Syndicate of the Tchad," the president of which is M. Vatel, a well known Parisian manufacturer.

As for the scientific results of the mission, they are briefly as follows: Complete itinerary from Ouada to the Tchad, comprising the almost complete course of the Gribingui and Chari, with the discovery of their affluents; reconnaissance of Lake Tchad; important astronomical observations; notes upon the inhabitants and the country; photographs, etc.—Condensed from L'Illustration.

## HOW DO CARRIER PIGEONS FIND THEIR WAY?

THIS question has been often discussed. In the Revue Scientifique, says The Literary Digest, M. Pierre Bonnier gives us the result of the latest investigations on the subject. He tells us that pigeons and other "homing" creatures find their way by no special sense, but merely by a high development of the power of "keeping their bearings," even in darkness, which all animals, even man, have in some degree, however small. This power he believes to depend on the construction of the inner ear. Says M. Bonnier:

"The name of 'sense of orientation' or 'sense of direction' has been given to the remarkable faculty that enables animals, at least those of migratory species, to go, even from considerable distances, directly to points about which the exercise of the known senses would furnish us with no information. In fact, it has long been asserted that none of the five senses separately, nor even several of them united, could explain the facility with which certain animals traverse unhesitatingly enormous distances across regions where the sense of sight or smell could give no aid toward a point that cannot be directly seen or smelled. This faculty, in whatever way it is to be explained, can doubtless be developed by practice; but it seems generally inborn and can be considered as a true instinct, giving to this word its biological signification of 'hereditary habit,' or, if preferred, that of 'congenital memory.'

"M. Viguier has adopted the hypothesis of a sixth sense, depending upon the semicircular canals of the ear, and having as its physiologic excitant the earth's magnetism. This theory has not been proved by its author, and has many objections. Nothing in the anatomy of the canals authorizes us to suppose that they have any magnetic susceptibility, or at any rate that they have anything more to do with magnetism than any other part of the organism. M. Viguier asserts that each canal lies in a plane, which is not exactly true for most of the vertebrate animals. . . . Finally, the unpublished observations of M. Reynaud show that electrical disturbances do not interfere with the exercise of the sense of direction in pigeons. . . .

"It seems to me that all theories that I know of show incorrect ideas about the proposition to be proved or disproved.

"In the first place, I do not think that we can prove the existence in animals of the ability to direct themselves at a distance and without objective aids toward an unknown point, unless they are guided in their course by older individuals of their kind who have already made the journey, or unless they themselves remember the road from having previously traveled over it.

"On the contrary, the term 'sense of direction' seems to me properly to apply only to the faculty that enables every animal, in course or at the end of a displacement, to retain an extremely clear and faithful notion of its situation, at a given moment, with relation to its starting point or inversely, no matter what its distance may be.

"This is the question at issue, I think. There are, in fact, two processes of orientation and direction in a medium unknown to us. We may get our bearings in relation to the point of arrival, that is, from in front; or, in relation to the starting point, that is, from behind. I think that the question has never been put in exactly this way.

"That the point of arrival may be known to us, it is necessary either that it should be visible, which is not the case, or that its position should be indicated objectively by known guides (and this is also generally not the case), or finally, that it should be the point of departure of a previous displacement, and I believe that this is always the case in all known examples.

"The point of departure is a guiding point that is of necessity known to us, and, by our consciousness and the memory of the whole series of our movements since starting, we keep in some sort continuously in contact with this point, or else, without preserving the recollection of our successive movements, we endeavor, perhaps unconsciously, to keep at each moment the notion of the direction of our motion. This is what we do when, arriving at an unknown city without intelligible and certain guides, we keep continually the notion of the direction of the railway station, our starting point, keeping our bearings from behind by the remembrance of the road that we have traversed, just as we get our bearings from in front by the sight of the road to be traveled. . . .

"The pigeon, carried in a basket, deprived of visual guidance, ignorant of the direction of the point of arrival, keeps, during the series of its successive displacements, the memory of the direction of its starting point, and when it has reached its destination it has never lost for a moment the exact notion of its component displacement or of the total displacement. It thus knows how to direct itself, either by retracing, stage by stage, the route over which it has been brought, . . . or if it is sure of its general direction, by striking directly across country. . . . This sense of direction may be of great preciseness, since it depends on the sense of altitude or position. . . .

"In man, this sense has been allowed to fall into disuse, owing to the employment of visual guidance, but still it exists; and among species for which the exercise of this instinct is a condition of survival and an important factor of evolution, it has attained extraordinary power by hereditary accumulation. It implies a wonderful memory, but is less surprising than certain instincts of metamorphosing creatures, or even than certain instances of human memory; it requires a great degree of precision in the notion of the smallest movements, but there are other sensorial habits that are quite as delicate; finally, it necessitates the power

of combining a series of elementary sensorial operations into a general notion of great certitude. . . . The term 'sense of orientation' is, perhaps, too comprehensive. I prefer that of 'sense of return.' Whatever it may be, this sense must be one of the nine functions that I have shown to appertain to the labyrinthine apparatus [of the inner ear]."

## EXPANSION OF PORCELAIN BODY AND GLAZE.

ON the invitation of the Limoges Potters' Syndicate, a series of investigations into sundry phenomena occurring in the manufacture of ceramic ware has been performed by M. Emilio Damour, under the auspices of the Société d'Encouragement pour l'Industrie Nationale.

Seeing that one of the great difficulties encountered by the potter is the cracking or peeling of the glaze, whether immediately after leaving the kiln or after a longer lapse of time, attention was first directed to this point; and it being established, without doubt, that the evil complained of is due to differences between the coefficients of expansion of the body and glaze, in consequence of which they contract at different rates during cooling, the accurate measurement of these coefficients was felt to be the first consideration, as affording a scientific basis for the adoption of remedial measures. It is true that in practice the difficulty has been to some extent overcome by the employment of boracic acid in the glaze, the elasticity of which is thereby increased, so that it can better support the strain exerted by the body, but this is a remedy less satisfactory than would be afforded by the removal of the cause of tension between body and glaze.

The method of measurement finally adopted was that of Fizeau, based on the phenomenon known as "Newton's rings," *i. e.*, the formation of a number of concentric rings in the colors of the spectrum, at and about the point of contact of a convex lens and a polished reflector; which rings move in proportion as the two surfaces are approached or withdrawn within certain limits. If instead of ordinary white light the monochromatic light of the sodium flame be employed, the rings will be alternately yellow and black. As the distance between the surfaces is increased, the rings converge toward a central point and disappear one by one, each disappearance corresponding to a movement equal to one-half the length of a wave of light, *i. e.*, to 0·0003 of a millimeter. Therefore, by counting the number of black spots succeeding each other at the center—whether appearing or disappearing—the rate of movement between the reflecting surface and lens can be measured with extreme accuracy.

The instrument employed was that of Fizeau, modified by Le Chatelier, and shown in the annexed illustrations, Figs. 1 and 2, Fig. 2 being an enlarged sketch of the nucleus of the apparatus. The substance under examination is prepared in the form of a prism, 2 to 3 centimeters (about 1 inch) long—the lower end, $\alpha$, $\beta$, $\gamma$, of which is ground flat and polished—and mounted on a metallic tripod, *S S*, the three supports, *a*, *b*, *c*, being on a plane parallel to that of the polished surface of the prism, and far enough from $\alpha$, $\beta$, $\gamma$ to allow the prism to expand freely. When the support is placed on a convex lens, the lower surface of the prism will be tangential to the lens, and the Newton rings will appear. The difference of expansion of the metal and test object occurring on the application of heat will alter the relative positions of the two surfaces, and so cause a centripetal or centrifugal movement of the rings, according as the expansion of the metal is greater or less than that of the substance of the prism; so that the value of the former being known, that of the latter can be deduced from the number of spots vanishing or appearing at the central point. The bi-convex lens supporting the prism and its mounting is carried on the projections rising from the vertical hollow cylinder, *C* (Fig. 1), through which light is reflected upward to the lens from a sodium flame, *y*, by means of a prism in the transverse underlying rectangular box, another prism therein reflecting the image of the Newton rings to a microscope tube, *X*. The instrument is supported in a vertical position on a tripod, *R*, resting on adjustable screws.

Heat is applied to the prism and its attachments by means of an annular water chamber, *A*, which fits on the upper end of the cylinder, *C*—leaving only a small opening connecting the air space around *S* with the external atmosphere—and rests on a large tripod, *T*, which also supports the Bunsen ring burner for heating the water.

The chief points to be attained in the prism mount, *S* (preferably constructed of platinum), are: The establishment of a firm, immovable connection between the prism and the support, on a plane perpendicular to the expansion to be measured; absolute independence of the two bodies along the axis of expansion; facility for the exact measurement of the prism longitudinally. The first object is assured by the horizontal circle of flexible steel carrying three equidistant blocks, through which project the fastening screws, *V*, with sharp-tempered points, which hold the prism tightly, being assisted therein by the tension of the spring. The second point is attained by the tripod form of the mount, and the third by the dimensions selected, the length of the legs (measured from the level of the screws, *V*), when screwed up until the tops are flush with the upper surface of the blocks, being exactly 20 millimeters; so that when the lower surface of the prism is on the same plane as the lower ends of the tripod, it too measures 20 millimeters from the points of support.

The specimens of porcelain body tested were, as a rule, supplied ready made and with polished extremities, by various porcelain manufacturers interested in the investigations, and others were polished by the experimenter and his colleagues. The samples of glaze were moulded in Pasteur filter tubes made at the Choisy faience works, and lined with a protective mixture of Fontainebleau sand and feldspar. Such as could not be prepared with a reflecting surface were fitted with a microscope cover glass, attached by Syrian asphaltum, or preferably a thin covering of enamel, ground true, and polished when necessary, the error due to expansion of the enamel being so minute as to be negligible.

To perform the experiment the apparatus is adjusted to the vertical, and tested by lighting the lamp and placing a polished plate on the lens, adjusting the microscope until the Newton rings are properly focused. The mounting of the prism, the most delicate part of the preliminary operations, is effected by inserting it from below between the points of the supporting screws, which, after the polished face of the prism is adjusted to the exact level of the lower extremities of the legs—by resting all three upon a glass plate—are screwed tight. The mount is then reversed and supported by a small hollow cylinder, or mortar, to leave the projecting head of the prism free, a lens of a little slighter curve than that of the instrument being then applied, whereupon the Newton rings will appear. Two of the legs of the tripod are next screwed round a little to incline the prism slightly and disperse

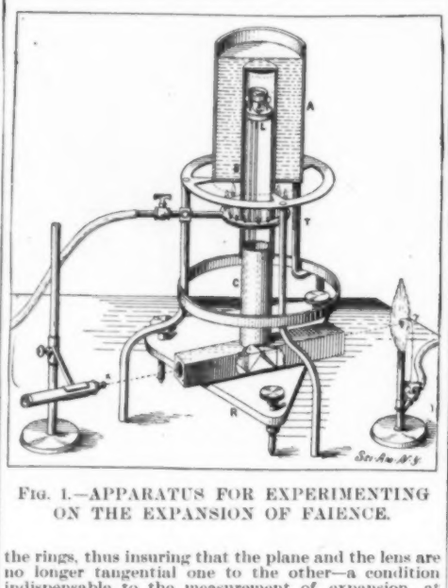


FIG. 1.—APPARATUS FOR EXPERIMENTING ON THE EXPANSION OF FAIENCE.

the rings, thus insuring that the plane and the lens are no longer tangential one to the other—a condition indispensable to the measurement of expansion, at least in cases where the expansion of the test object is superior to that of the metal of which the mount is made—and that there is a little room for the eventual lengthening of the prism; as may be proved by pressing gently on the head of the latter, when, if the adjustment is good, a large number of rings will appear radiating from the center.

The prism and mount are put in position on the apparatus, the water chamber is fixed in its place, and after leaving the apparatus until an equilibrium of temperature is established throughout (which will take about a quarter of an hour), the temperature of the water chamber, the state of the center of the colored rings, and the time are noted, the Bunsen lamp lighted, and the movement of the rings thenceforward minutely observed. After an initial period of irregularity, the movement will become constant, the rings disappearing at regular intervals until the temperature of the inner air chamber attains 100° C. (the boiling point of the water), when, after the rings have exhibited no movement for a quarter of an hour, the experiment is at an end. It was found by direct investigation that the mean rate of expansion between 15° and 100° C. is identical with that occurring at higher temperatures, so that there is no practical necessity for carrying the experiment further than the above-named

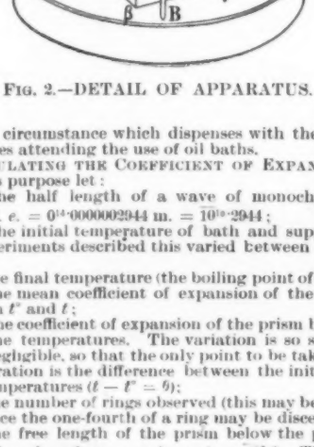


FIG. 2.—DETAIL OF APPARATUS.

limit, a circumstance which dispenses with the inconveniences attending the use of oil baths.

CALCULATING THE COEFFICIENT OF EXPANSION.—For this purpose let:

$\lambda$ = the half length of a wave of monochromatic light—*i. e.* = $0^{14}\cdot0000002944$ m. = $\overline{10}^{10}\cdot2944$;

$t'$ = the initial temperature of bath and support (in the experiments described this varied between 12° and 22° C.);

$t$ = the final temperature (the boiling point of water);

$\delta$ = the mean coefficient of expansion of the mount between $t'$ and $t$;

$x$ = the coefficient of expansion of the prism between the same temperatures. The variation is so small as to be negligible, so that the only point to be taken into consideration is the difference between the initial and final temperatures ($t - t' = \theta$);

$f$ = the number of rings observed (this may be a fraction, since the one-fourth of a ring may be discerned);

$l$ = the free length of the prism below the point of suspension, *i. e.*, 2 cm., or in meters $10^{2}\cdot2$. The only correction required is when the adjustment lens is too convex.

The displacement $f\lambda$ between the base of the prism and the lens is equal to the difference in the increase of length of the prism and its mount.

$$\pm f\lambda = [t - t'] t (x - \delta);$$

the + sign being used when the body expands more than the support, *i. e.*, when the rings move outward from the center, the — sign being used in the converse case. The coefficient will be found by the formula:

$$x = \delta \pm \frac{f\lambda}{\theta l}$$

or, by substituting the numerical value, by

$$x = \delta \pm \frac{f}{\theta} 10^{-4}1472$$

presupposing the coefficient of expansion of the mount to be known. This is best ascertained by direct experiment with a quartz prism, and was for the platinum mount employed an average of $\delta = 11\cdot100$.

This gives the definite numerical formula for temperatures between 15° and 100° C. as:

$$x = 10^{-7}\,[1110 \pm \frac{f}{\theta} 14720]$$

$$\frac{x}{100{,}000{,}000} = 1110 \pm \frac{f}{\theta} 1472$$

which formula was employed throughout.

COEFFICIENTS OF EXPANSION OF VARIOUS CERAMIC BODIES AND GLAZES.—After an ineffectual attempt to establish, from the behavior of sundry simple borates and silicates, a simple law of relation between chemical composition and coefficient of expansion which would be capable of general application and serve as a guide in the study of industrial glazes, the examination of the actual materials used in practice was proceeded with.

Porcelain Bodies and Glazes.—These being already in a high state of perfection, afforded an interesting subject for study, to ascertain whether the same is due to the correspondence of expansion between the body and glazes theoretically deemed necessary. The results were as follows:

| Porcelain Body. | | Glaze. | |
|---|---|---|---|
| Sèvres, hard .. | $10^{-7}$ 334 | Sèvres, new. .. | $10^{-7}$ 514 |
| " new.... | " 523 | Limoges (*a*)..... | " 526 |
| Limoges, (*a*).... | " 326 | " (*b*). ... | " 523 |
| " (*b*) ... | " 382 | " (*c*)..... | " 534 |

and confirm the high quality of the new Sèvres ware. The Limoges porcelain differs from the glazes in expansion, the tendency of the latter being in the direction of cracking, while that of Sèvres tends to peel, which is an advantage, since the glaze can resist compression better than traction.

Faience Bodies and Glazes.—The results of the experiments were verified by those obtained with the same materials in practice.—Pottery Gazette.

## STEAMING RADIUS OF OUR NAVAL VESSELS.

THE steaming radius of our naval vessels has been a subject of interest, and is clearly one of great importance in naval warfare. It is clear that speed and coal carrying capacity may determine success or defeat, steam colliers being at best but a very unsatisfactory, though necessary, adjunct to a naval formation. The comparative coal capacities of our principal ships has been formulated by the Bureau of Steam Engineering as follows:

| Ship. | Type. | Coal bunker capacity | Steaming radius on this coal at most economic rate. | Steaming radius on this coal at maximum speed with forced draught. |
|---|---|---|---|---|
| Iowa..... | First-class battleship | Tons 1,790 | Knots a6,000 | Knots b2,355 |
| Indiana..... | " " | 1,550 | 4,805 | b2,671 |
| Massachusetts..... | " " | 1,500 | 4,797 | b2,265 |
| Oregon..... | " " | 1,540 | 5,205 | c2,448 |
| Brooklyn..... | Armored cruiser. | 1,300 | 4,342 | b1,404 |
| New York..... | " " .... | 1,200 | 4,486 | b1,244 |
| Columbia..... | Protected cruiser . . | 1,600 | a7,000 | b1,840 |
| Minneapolis..... | " " ... | 1,430 | 6,824 | b1,565 |
| Olympia.. ..... | " " .... | 1,100 | 6,165 | c1,498 |

a Estimated.
b From official trial, actual figures.
c From official trial on basis of 2·4 pounds of coal per indicated horse power.

**The World's Consumption of Coffee.**—The following statistics on the consumption of coffee from 1893 to 1897, in the chief countries of Europe and in the United States, are given by the Revue Scientifique, Paris:

| Years. | Europe. Tons. | United States. Tons. | Total. Tons. |
|---|---|---|---|
| 1893... ... | 271,498 | 258,117 | 519,615 |
| 1894... ... | 272,191 | 238,822 | 531,013 |
| 1895..... | 277,400 | 260,880 | 538,280 |
| 1896... .. | 291,150 | 267,880 | 559,030 |
| 1897..... | 305,150 | 318,170 | 623,320 |

"It will be seen that in 1897 the consumption of coffee in the United States exceeded the total use in Europe. The European countries that use the most coffee are Germany (136,390 tons) and France (77,310 tons); England uses only 12,420 tons, about the same quantity as Italy (12,500 tons)."

**The St. Gothard** Railway Company, in Switzerland and Italy, report very satisfactory results from the use of steel sleepers on their lines. In 1882, when the road was opened, it was laid with wood sleepers, but as these have had to be replaced, it has been done with steel instead, and at the present time, 70 per cent. of the road is laid on steel ties. The sleepers, weighing 163 pounds each, are 8·85 feet long. The cost, when new, with attachments, is $1.95, which, allowing for the value of the old material, is reduced to $1.62 per sleeper. In tunnels, wooden ties are preferred, as they are not liable to rust, but in other places the deterioration due to rust is not at all serious.

## ENGINEERING NOTES.

**The passenger** rolling stock of the Boston and Albany Railroad has for some time been equipped with a compressed air whistle apparatus, which consists of a line of small rubber tubing connecting with the air brakes and leading to a whistle in front of the engineer in the cab. Should the train break apart, the whistle will immediately notify the engineer just as the parting of the air brake tubes automatically sets the brakes. An order was issued providing that all passenger rolling stock belonging to the Boston and Maine Railroad be thus equipped before July 1, and this has been done.

**House shifting** has long been practiced on a grand scale in the United States. The Continent had not as yet indulged in any experiment. In November last, however, a house which interfered with an enlargement of the Aschaffenburg railway station had to go. It is a house of 40 feet front, 35 feet depth, with cellars, ground floor, first story, and garrets, and as the partition rested on the cellar vaults, the cellars had to travel too. A sort of canal had to be built for the purpose. The motion took place on a gradient of 10 per cent., because the new site was four feet higher than the original site; the canal was paved with railway sleepers, on which the six roller paths rested. When the iron girders had been fixed through holes in the walls, the whole house was lifted four inches, and then pushed along by means of six jacks. The journey of 350 feet was accomplished in seventeen days, the maximum speed being 34 feet a day. The girders were finally withdrawn, and the house lowered on its new foundations. Everything went well with the 750 ton house; not a single window pane cracked, and the costs of the whole operation, $3000, were exactly half of what the taking down of the house and erecting a new one were estimated to have cost.

**The newest** wonder in American engineering has just been inaugurated at Houghton, Mich., viz., the Red Jacket shaft of the Calumet and Hecla—the greatest mining shaft in the entire world. It is 4,900 feet deep, and compared with it the deep silver mines of the Comstock lode in Nevada, or the wonderful mines of Austria, worked for many centuries past, are but shallow pits. There are six compartments, each equal in size to an ordinary mining shaft, four of these being used for hoisting rock and lowering timber, one is used for the ladderways, and the sixth and last compartment carries the wires and pipes for telephones, light, power, water, and compressed air. The underground workings of the shaft are laid out with mathematical accuracy, the undeviating course of the copper-bearing lode allowing work to be planned thousands of feet ahead of the mineral picks. The great pumps which free the mine of water are operated interchangeably by compressed air and electricity. The power drills which bore the holes for the dynamite cartridges are run by compressed air alone, and there are more than three hundred of these drills, each doing the work of a dozen men, working both day and night, in the Calumet and Hecla mine.

**Having analyzed** the powder found in fthe pits, M. Olroy, a French engineer, gives in an article the results of his investigations in the pitting of boilers. He found that the powder contained 86·26 per cent. of peroxide of iron, 6·29 per cent. of grease and other organic matter, and 4·25 per cent. of lime salts. He discusses the pitting of feed heaters, boilers, etc., mentioning the conditions under which pitting most frequently occurs. He also cites certain experiments in which a polished iron bar was first immersed in a natural water containing much oxygen and no lime salts. The bar gradually rusted, but the corrosion ceased when the oxygen was used up. The bar was then removed, repolished, and put back, after which it remained perfectly bright. Repeating the experiment with water containing lime, the rusting was much less complete, the lime salts forming a protective layer on the iron, but on polishing this off corrosion recommenced. In distilled water the bar remained quite bright. The corrosion is much more rapid if the water contains carbonic acid gas as well as oxygen. In this case a voltaic action takes place. The rust first formed is electropositive to the iron, which then dissolves away, decomposing the water. It is for this reason that in cases of pitting it is essential that all traces of the iron peroxide should be cleaned from the metal, or the rusting will continue.—Scientific Machinist.

**A critical** temperature in the working of both iron and steel is at the so-called "blue heat," which is from 450° to 600° Fah. Here, iron and steel are much more brittle than when cold or at redness. This heat, however, does not seem to leave any bad effect on the iron. But if the piece be worked in this range of temperature, it will retain the brittleness after cooling and show a great loss of ductility, as measured by the bending test, although it has not been conclusively proved that there is a loss of ductility when the piece is pulled apart by static tensile stress. The poorer the iron, the more susceptible it is to the "blue heat." In other words, the poorer the iron the more dangerous it is to work at that heat. The danger to steel, at the "fatal blue," is more pronounced than in iron, but it exists to a greater or lesser extent in all grades of iron. It is also more noticeable in a descending than in an ascending heat, and is especially marked in work having sharp corners, which has been worked at the blue heat. The loss of ductility and of shock-resisting power is not due to any incipient cracks, as can be proved by the restoration of the former qualities of the metal by reheating to redness or by annealing. There seems to be some close relation between the effects of "blue shortness" and "cold working," but the injurious effects of the former are more marked than those of the latter. While blue working lessens ductility, it is not always fatal to the metal. Examples may be cited in proof of this. In hand riveting the operator usually continues hammering while the rivet cools past this critical temperature, and yet few rivets have been known to fail from this cause alone. According to a paper recently read by Prof. H. E. Smith before the Engineers' Club of Minneapolis, on "The Effects of Heating and Working on Iron and Steel," blue working, without subsequent annealing, is prohibited in boiler work for the United States navy, but not for hull work.

## ELECTRICAL NOTES.

**Berlin, Germany,** has 9 telephone centrals and 37,000 subscribers. New York has only 18,000 subscribers.—Uhland's Wochenschrift.

**From recent** statistics it appears that 98 per cent. of the continuous current central stations in Germany are provided with accumulators, the total capacity of which is 31 per cent. of the total power of these stations. Many that previously did not have accumulators have now added them as the most convenient way of enlarging the station.

**Lord Rayleigh** informed his audience at the last lecture of the season at the Royal Institution that by means of the telephone a current of one-millionth of an ampere can be made audible. The action of self-induction was shown by inserting a bundle of wires into a coil which made the connection to the supply. The effect was shown by means of flames, and when the effect was produced the light became dimmer at once. Speaking affected the flame visibly, clapping of hands extinguished it. An index showing the variation of pressure caused by a sound was thrown on the screen. A threepenny piece placed on Prof. Hughes' inductive balance produced a visible effect on the flame.

**United States** Consul Morris writes under date of Ghent, May 21, that plans and specifications for the electric railroad between Mons and Bossu have been published by the Minister of Railways; they also include provisions for a complete electric power house. The estimated cost is $125,450, of which $46,320 is for the rolling stock. There is a clause providing that the builder must operate the line for a fixed sum during two years under the government's control. All the material necessary for the road must be made in Belgium. The entire work must be completed within twenty-five weeks after the award, and the line must be opened, at the latest, in February, 1899. The road will be about seven miles long.

**In a** reported interview with an officer of the "Cristobal Colon," after the destruction of Cervera's fleet off Santiago, the value of searchlights in harbor defense is again shown. The officer was asked about the Hobson expedition, and in answer said: "We were much surprised, and at the first alarm believed that a torpedo boat attack was going on. The shore batteries opened up and the ships used their rapid fire guns. The dynamos were not going, however, and we had no searchlight, so that we could not find the object. We did not sink her with our batteries or our mines. She sunk herself with her own torpedoes by blowing out her bottom." This shows that the Spaniards were either desperately short of coal or else that they did not understand the value of the searchlight as an aid to modern warfare.

**The firm** of Queen & Company, Philadelphia, Pa., have placed in the market a new photometer for measuring the candle-power of incandescent lamps. Cast-iron pedestals support the metal photometer bar, and carry stages for the support of the lights, screens, etc. There is a rheostat on one pedestal and the lamp is fixed on the other, the rheostat being for the control of the potential of the standard. It is about 800 or 1,000 steps, and permits of perfect adjustment. Another rheostat on the right regulates the current on the test lamp. The graduated bar is inclined at 45°; the graduations are lighted by the lamp under test. The screen may be either of the Bunsen or Lummer-Brodlum type, is mounted on a truck, and may be rolled along the bar wherever desired. A milled lead permits of close adjustment when balance is nearly attained.

**According to** Maxwell's theory, ordinary conductors should be opaque to light. Electrolytic conductors do not come under this rule. If glass, therefore, is a conductor at high temperatures, the conduction must, as a first approximation, be regarded as electrolytic. A. Vosmaer, in "Electra," describes a striking experiment illustrating the conductivity of glass. Two electrodes terminating in glass rods are joined to the poles of a high tension transformer. Nothing happens until the rods are heated by a Bunsen burner, when an arc is formed between them. The arc itself keeps the rods at conducting point, but as a rule the rods break, owing to some portion acquiring greater conductivity than the rest and then taking all the current. If, before this happens, the electrodes are separated, a spark discharge sets in, and, on a further separation, a brush discharge. On bringing the electrodes together again, the arc is re-established.

**At a** recent meeting of the Royal Society, Prof. Andrew Gray and Prof. J. J. Dobbie contributed a paper on the connection between the electrical properties and the chemical composition of different kinds of glass. Experiments have lately been made with the object of determining the circumstances which affect the conductivity and specific inductive capacity of glass, and as Prof. Gray and Dr. Hopkinson had previously found that potash and soda lime glasses have a higher conductivity than flint glasses, some glasses richer in lead oxide than any formerly available—and in some cases practically free from soda—were made for the purpose of the test. The object in providing such special glasses was to discover whether diminution in the amount of soda and increase of lead oxide would still further diminish the conductivity. The experiments of the authors were of a thoroughly comprehensive character, the measurements made with extreme care, and the specimens of glass tested in every case carefully analyzed. The anticipation that conductivity would be decreased by an increase of lead oxide and a diminution of soda in the glass was fully borne out. The specific resistance of the lead potash glass was for one certainly above $18{,}000 \times 10^{10}$ ohms at 100° C., for another above $35{,}000 \times 10^{10}$ ohms at all temperatures up to 135° C. The specified resistance of barium glass was also very high, and, what was remarkable in this glass, there was hardly any trace of dielectric polarization. It was also found that the almost complete replacement of the potash in a lead glass by soda diminishes the specific resistance. It is intended to pursue the experiments on the electrical and mechanical properties of the barium glass, and glasses of other composition, and for this purpose special glasses of as nearly as possible prescribed compositions are being made.—Pottery Gazette.

## SELECTED FORMULÆ.

**Foot Powder.**—Most of the powders employed for tender feet contain talcum and salicylic or boric acid after the character of the "salicylated powder of talcum" of the National Formulary.

| | |
|---|---|
| 1. Salicylic acid | 1 drachm. |
| Boric acid | 2 " |
| French chalk | 6 " |

Mix and perfume with a drop of an essential oil.

| | |
|---|---|
| 2. Orris root | ½ ounce. |
| Boric acid | 1 " |
| Starch | 2 " |
| Fuller's earth | 2 " |

Powder separately and mix. May be perfumed if desired.

| | |
|---|---|
| 3. Mercuric chloride | 2 grains. |
| Sodium salicylate | 2 ounces. |
| Powdered talcum | 2 " |

Dust a little of the powder in the socks every morning.

**Lamp Oils for Cyclists.**—

| | |
|---|---|
| 1. Camphor | 1 ounce. |
| Castor oil | 2 " |
| Petroleum | 4 " |
| Olive oil | 20 " |

Dissolve the camphor in the oils.

| | |
|---|---|
| 2. Paraffin oil | 1 ounce. |
| Colza oil | 7 " |
| 3. Camphor | 1 " |
| Petroleum | 4 " |
| Colza oil | 20 " |

—Pharmaceutical Era.

**New "Tin Can" Label Paste.**—

FOR PAINT AND VARNISH CANS.

| | |
|---|---|
| a. Brown sugar | 2 lb. |
| Boiling water | 16 fl. ounces. |
| b. French gelatin | ½ ounce. |
| Water | 4 fl. " |
| c. Corn starch | 12 ounces. |
| Beat up with cold water | 12 fl. " |
| Pour the batter into boiling water. | 32 " |

Continue boiling c, if necessary, until the paste is translucent. Dissolve a and b separately, and then mix with c. Paste for tin should not be too thin, and the tin should be free from grease. New tin generally has an oily or greasy surface, due to the tallow or oil used in the plating process. The grease may be removed with an alkali or with benzine, but in a factory where much labeling is done, it is better to slightly roughen the surface of the tin where the label is to be placed with a piece of fine sandpaper, No. 0. This paste is very adhesive, and labels pasted with it will adhere nicely, even in a damp place. The sugar, in its composition, also renders it proof against cracking when exposed to a dry atmosphere.—Western Painter.

**Artificial Apple, Cherry, and Grape Ciders.**—The word cider applies only to fermenting or fermented apple juice, and has no recognized standing as applied to any other fruit. Grape juice, while fermenting, is called must, and the fermented juice is wine. The fermented juices of the berries, other than the grape, are also called wines—as cherry wine, blackberry, mulberry, raspberry wine, etc. We give a formula for an artificial cider:

IMITATION CIDER.

| | |
|---|---|
| Tartaric acid | 2 parts. |
| Common brown sugar ("New Orleans") | 35 " |
| Rain water | 200 " |
| Yeast | 1 " |

Put into a clean keg or cask, with the bung out, and let stand in a warm place twenty-four hours. Add 25 parts of rectified spirit of wine, bung tightly, and let stand forty-eight hours, when it will be ready for use. The above is improved by adding to each gallon of spirit from 1 to 2 fluid drachms of apple essence (obtainable from dealers in bar supplies, or probably from any wholesaler). This gives it the apple aroma and flavor.—National Druggist.

**Destroying Roaches.**—A good plan is to render the place which the roaches frequent perfectly dry, and then coat the boards or shelves with a strong decoction of quassia. When this has become thoroughly dry, cover the boards, etc., with clean paper. Other bitter substances may be used in place of quassia. In places where articles of food, drink, or clothing are not likely to be placed, some poisonous substance, such as corrosive sublimate, may be employed. But great care should be taken that it be not applied in such manner that it can eventually be brushed off in dust. A good plan is to dissolve a little shellac in solution of borax, to add a very small quantity of bichloride, and to paint the solution into the cracks and corners. If water or dampness is kept away from the shelves or closets, the roaches will leave the place of their own accord.

The following formulas are also recommended:

| | |
|---|---|
| 1. Plaster of Paris | 8 ounces. |
| Oatmeal | 16 " |
| Sugar | 4 " |
| 2. Angelica root in fine powder | 100 parts. |
| Essence of eucalyptus | 20 " |

Scatter at night plentifully around the haunts of the pests.

The Era Formulary gives this one:

| | |
|---|---|
| 3. Thymol | 2 parts. |
| Salicylic acid | 2 " |
| Alcohol | 200 " |
| Oil of lemon | 1 " |

This preparation makes no stain and is said to kill roaches and vermin immediately. The odor is not unpleasant and is quickly removed by airing the room.

| | |
|---|---|
| 4. Chamomile | 2 ounces. |
| Borax | 12 " |
| Insect powder | 2 " |
| Plaster of Paris | 1 " |
| Sulphur | 3 " |
| Crude arsenic (so-called cobalt) | 120 grains. |

—Pharmaceutical Era.

## THE CULTIVATION OF THE GRAPE-VINE.

By M. DAL PIAZ.

IN cultivating grape-vines the first things to be considered are adaptability to climate and local conditions. An improvement in the quality of the fruit is also to be kept in view, for not in vain has man troubled himself through centuries to train the grape so that it should meet with his various requirements. That man has succeeded in bringing about the desired result is due, not so much to his own ingenuity, as to the extraordinary adaptability to changing conditions possessed by this hardy plant.

In order to exercise a favorable influence on the grape, the vine must be cultivated by methods that vary with the climate, soil, etc. By employing a suitable method of cultivation, the desired result can be obtained with more or less success. It is the purpose of this article to describe several of the methods commonly employed in northerly and southerly climates.

A classification of the methods employed would simplify this review, but since the various ways of growing the vine are numerously modified and combined, such a classification would result in obscurity. It would, however, be possible to select only those methods of cultivation which could be brought into a class, leaving the exceptions to be treated separately. In order, however, to avoid all confusion, a certain order will be maintained, beginning with those methods of cultivation that require very short mature wood and concluding with methods of propagation requiring longer mature wood.

In training vines with short mature wood, the "heads" are formed by cutting the wood very short. These "heads" usually make their appearance during the first year, the shoots being cut close to the ground. One or two eyes only are retained, so that in the fourth year, each vine has grown a rather stout head.

The closest pruning known is practiced in Austria. In the method here in vogue the fruit-bearing canes of the previous year are cut away as far as the old wood. In order to produce a suitable form of head the laterals should be cut down to eyes, while the uprights growing in the center are cut entirely away, care being also taken to remove the shoots. This method of pruning is not suited to all varieties of grapes.

In many parts of Austria and Hungary "spur" pruning has been introduced and variously modified. The heads are uncovered in the spring and the fruit-bearing canes are cut down to two eyes. The grapes hang very near the ground and are much exposed to the sun, a condition somewhat alleviated by the dense foliage. This method of pruning can be used with profit in vineyards subject to frosts in severe winters, since, by reason of their position, the undermost eyes can escape the danger of being frost bitten.

In Southern Austria the vines are usually supported by stakes, to which the canes are tied (Fig. 1 *a*). In the southern part of Hungary, however, the canes are allowed to grow without any support and are kept in place merely by tying them together so that the upper portions can be cut off at regular intervals, as shown in Fig. 1 *b*. The close pruning practiced in Banat and Syrmia can result only in producing a very short-lived vine. The pruning found in Charente (Aunis) and illustrated in Fig. 2 is interesting in so far as the wood is permitted to grow somewhat longer, but is, nevertheless, well pruned. Two or three eyes are usually retained, particularly in the variety Folle Blanche. The red grape variety Balsac is not cut so short. The vines are unsupported, but are kept in place by binding them together. During the summer the vines are not treated. Greater care, however, is given to the soil.

The heads are more often seen with longer wood, as illustrated in Fig. 3 *a*. As practiced in Rheingau this system of propagation provides for two canes having from six to ten eyes, the canes being tied up obliquely. The vine itself is supported by a long stake to which are vertically tied the shoots that are to bear fruit during the following year. The bearing vines are tied to short pegs in such a manner that they shall be inclined at an angle of forty degrees; by this means, the grapes are carried away from the wood-producing shoots and yet are kept rather near the soil. Riesling wine is produced from Rheingau grapes cultivated in this manner.

In a method (Fig. 3 *b*) which has been generally discarded for the one illustrated in Fig. 3 *a*, three vines were planted at a distance of about three feet from one another and provided with rather long stakes. Two vines were then pruned down to laterals, bent down, and tied each to a stake. Of these stakes, each had to support the bearing vines of two plants. The vine was pruned down to two or three eyes which were trained so as to produce a stout wood growth. This method of culture has many shortcomings and is, consequently, no longer used in newly planted vines.

"Head" pruned vines, with canes or bows somewhat similar in appearance to the Rheingau vines already described, are met with in Würtemberg (Unter-Türkeim) and in Bavaria (Würzburg). In the Palatinate a like method is found which employs short arms tied up on wires (Fig. 4), so that the vines are brought within a yard of one another. The vines are, furthermore, pruned to two or three eyes. These eyes produce the fruit-bearing shoots of the next year. The green shoots are carefully tied up. In spite of the low position of the vines, shoots can be trained to a considerable length.

Many growers also train their canes horizontally, thus bringing the grapes very near the ground. This method has the disadvantage of requiring very long canes, in order that the latter may be tied up to the proper stake. In other respects the position of the fruit-bearing canes is good. Since the weight of the fruit, however, brings the vines very close to the earth, it would be advisable to cut the canes rather short and tie them to some short support in the manner shown in Fig. 5, to the right. Fig. 5, to the left, shows the first described method, in which all horizontal canes are tied in one direction, while in the second described method the canes are trained one on each side, and tied to a short stake.

In a method of propagation known as the "Hungarian" method, we find a head producing rather long canes, one of which is partially embedded in the soil, the emerging end virtually constituting a separate plant having two or three eyes (Fig. 6 *a*). The embedded cane takes root in the course of the spring and summer, the shoots at the end of the buried cane being, in addition, nourished by the mother-plant. Fine grapes can be produced by this method, but the fruit on the end of the embedded cane is never so good as that of the main plant.

In Styria the vine is trained in a way somewhat different from the "Hungarian" mode. The cane is also embedded in the soil (Fig. 6 *b*), but does not emerge again to form a new plant. This method has an advantage over its "Hungarian" rival in not weakening the main plant or exhausting the fertility of the soil. In the "Hungarian" method, moreover, the vineyard will require considerable fertilizing after a time, if the productive power of the soil is to be kept undiminished in vigor. The Styrian culture, moreover, has the further advantage of keeping the fruit near the ground and yet at such a distance therefrom as to permit a ready cultivation of the soil.

A method of culture first tried by I. Guyot has been applied with some success. This method is chiefly adapted to regions in which the fruit-bearing wood is not likely to freeze, and in which frequent pruning must be resorted to in order to curb the rapid growth of the vines. Care must be taken to keep the fruit as

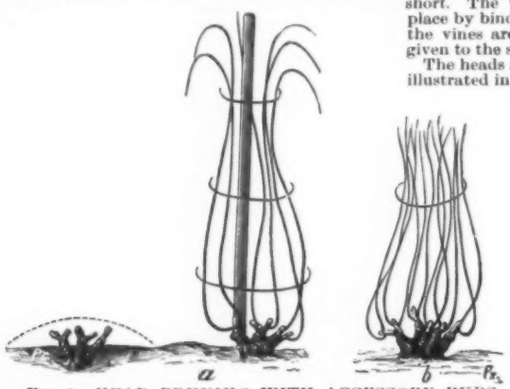



FIG. 1.—HEAD PRUNING WITH ACCESSORY BUDS.

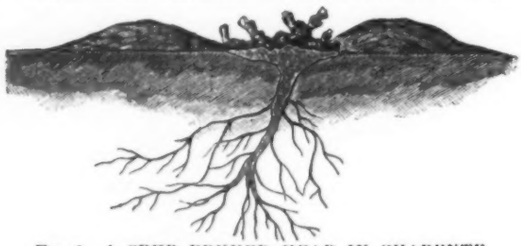


FIG. 2.—A SPUR PRUNED HEAD IN CHARENTE.

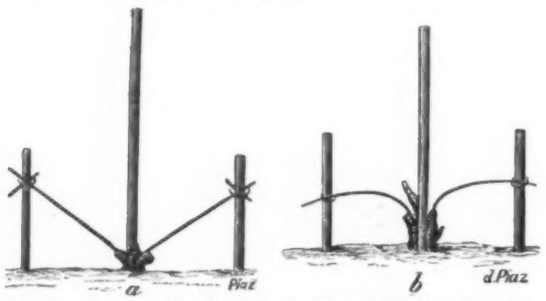



FIG. 3.—HEAD PRUNED VINE SUPPORTED BY STAKES.

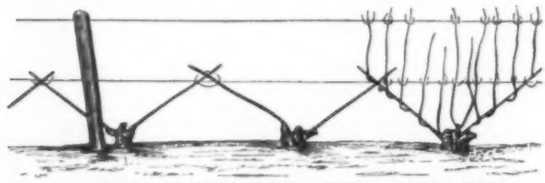


FIG. 4.—HEAD PRUNED VINES WITH CANES TIED TO WIRES.

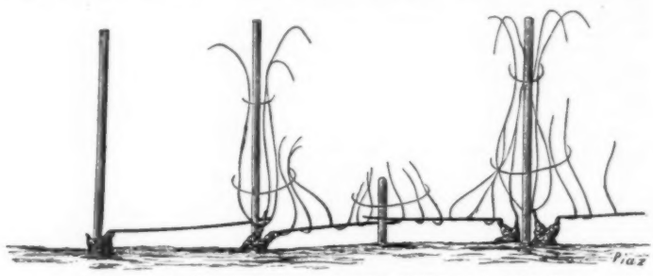



FIG. 5.—SYSTEM EMPLOYING HORIZONTAL CANES.

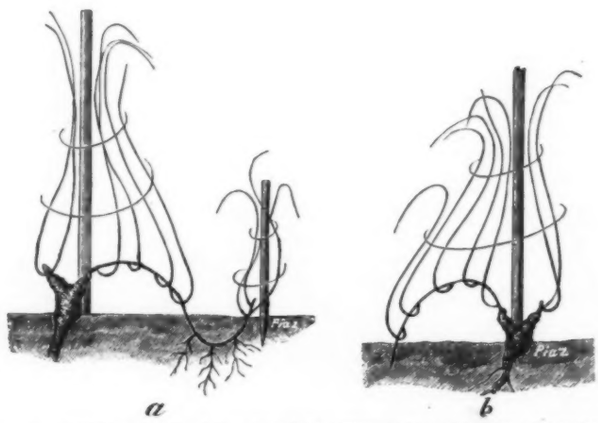



FIG. 6.—HUNGARIAN AND STYRIAN SYSTEMS OF PROPAGATION.

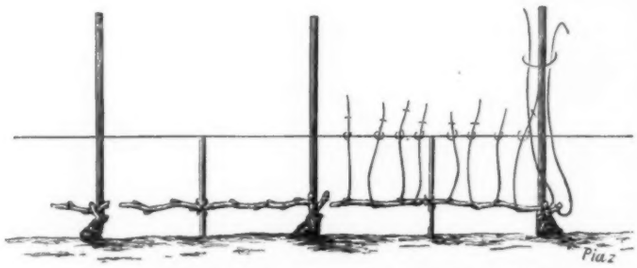



FIG. 7.—GUYOT'S SYSTEM OF HEAD PRUNING.

a proper distance from the ground. The vines are set in squares one yard apart and closely "head" pruned. Each plant is supported by a long stake, while in the spaces between the plants stakes are located, one-half the size of the larger ones (Fig. 7). The summer shoots are tied to horizontal wires sufficiently strong to hold all the stakes firmly in position.

A method of cultivation common in Beaujolais (Fig. 8 *a*) consists in training a tall head with old mature wood cut down to three spurs, which spurs during the course of the year become arms. This method is somewhat similar to the stem-training (shown in Fig. 8 *b*) usually practiced in Bas-Languedoc (Herault). The vines are placed rather closely together (less than three feet) and pruned down to two or three eyes. Sometimes the superfluous shoots are disbudded. Up to the twelfth year the vines are supported by stakes. After the twelfth year the stakes are totally discarded and the shoots of adjacent plants are tied together so as to form a bow to support one another.

In Bas-Languedoc, the vines are trained in a way well adapted to the conditions usually met with in southern countries. The vines are planted 1½ to 1¾ yards apart, in squares, or in rows, 2 yards apart. The stems are trained with six to ten arms, each of which is pruned with spurs having two eyes. The summer shoots are untreated and unsupported and shade the ground. The soil is usually cultivated with the plow.

These and similar methods of propagation are to be commended to growers who are usually favored with large crops. But little cultivation of the soil and but little pruning of the vines are required. "Spur" pruning of this kind is, however, applicable only to those varieties of grapes that bring forth fruit-bearing shoots on the first eyes of the vine. It is this very condition which has prohibited the general use of the preceding methods of pruning in Italy, because the varieties of grape there cultivated absolutely require long wood in order to bear fruit. If, however, it is desired to cultivate such varieties of grapes by the methods already indicated, then the long, fruit-bearing wood must be cut, as shown in Fig. 9. Should it not be desired to allow the canes to hang freely, they can be tied to one another in the manner illustrated.

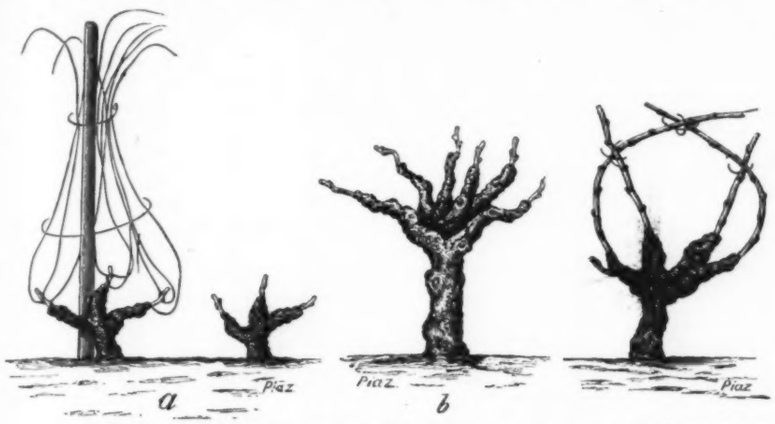



FIG. 8.—METHODS EMPLOYED IN BEAUJOLAIS AND BAS-LANGUEDOC.

FIG. 9.—A STEM TRAINED WITH LONG WOOD.

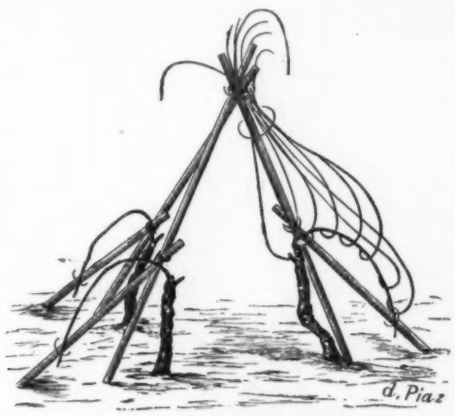



FIG. 13.—CÔTE-RÔTIE SYSTEM.

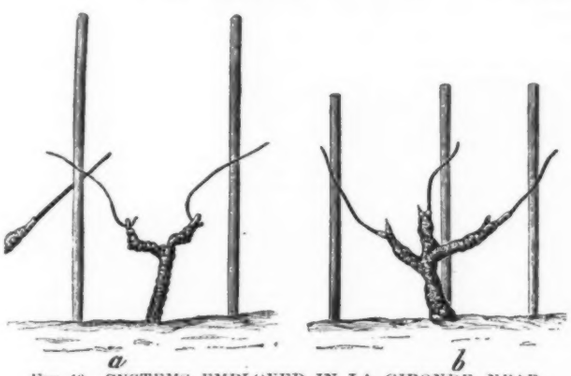



FIG. 10.—SYSTEMS EMPLOYED IN LA GIRONDE, NEAR BORDEAUX.

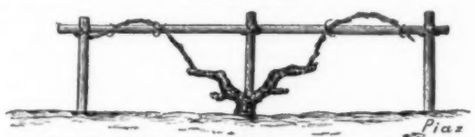



FIG. 11.—SYSTEM OF TRAINING VINES IN MÉDOC.

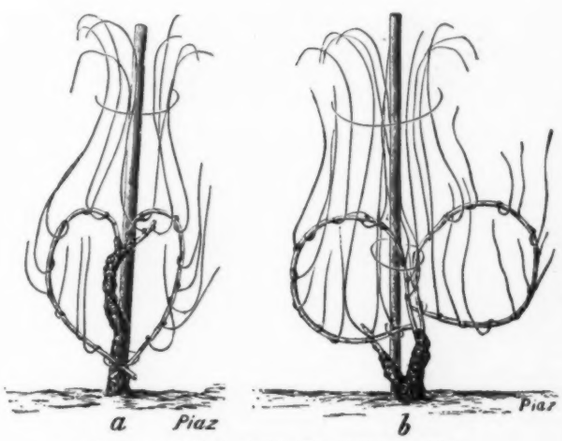



FIG. 14.—VINES TRAINED WITH BOWS.

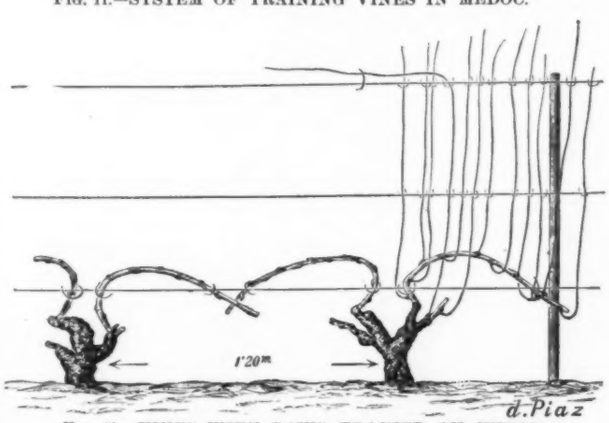



FIG. 12.—VINES WITH BOWS, TRAINED ON WIRES.

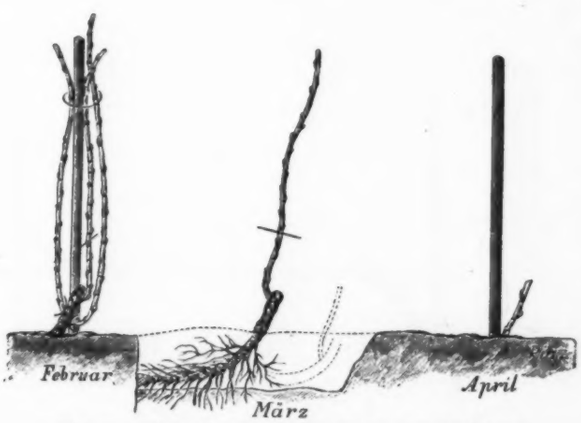



FIG. 15.—SYSTEM EMPLOYED IN LA CHAMPAGNE.

In La Gironde, shorter stems having long arms are trained. The vines, as shown in Fig. 10 *a*, are bound to stakes or wires, a custom generally practiced in the vicinity of Bordeaux. In the method illustrated in Fig. 10 *b*, frequently met with on the banks of the Gironde, the vines are tied to three short stakes.

A method more frequently seen is the "half-bow" system of training the canes—a system which has been subjected to many modifications. In Médoc, the vine-growers usually train two arms on a short stem, the canes being bent down and tied to a frame as shown in Fig. 11. In this, as well as in other methods, the lowermost arms are cut back so as to produce fruit-bearing canes for the next season. Exactly similar to the Médoc system is that practiced in Nackenheim, in which, however, a double supporting frame is employed. The "bow" system is also found near Heidelberg, Neustadt, and Edenkoben. This method of training the canes can be used to good effect on wire frames. When growing on a large scale, the canes should be bent to half-bows in order to attain a uniform growth of the individual eyes. Fig. 12 illustrates a method of this nature which has given good results. According to this system, the stems are pruned very short, only two arms on a side being allowed to grow. From fifteen to thirty eyes are retained and evenly distributed between two long canes and two arms held in reserve for renewal. The undermost wire is about a foot from the ground, and to it are tied the fruit-bearing canes. These canes are so arched that the most pronounced bend shall be near the old wood. By this means the first eyes receive considerable nourishment and can be used in the next year as fruit-bearing wood without providing too long a stem. If, however, the old wood already extends above the first wire, then, with the assistance of the arms held for renewal, a new growth of wood can be undertaken. The shoots are fastened to the second and third wires. If the third wire be discarded, then each wire must be further supported by a thin stake, upon which are bound the bearing canes of the following year.

Another "bow" system is found on the banks of the Rhone (Côte-Rôtie) and is illustrated in Fig. 13. The vines are planted in the manner shown, and are supported by stakes bound together to form a pyramid. Each of the stakes is provided at its base with a smaller

stake, to which the downwardly bent canes are tied. The shoots are tied up to the larger stakes, and with their leaves shelter the fruit from the rays of the sun. This system is one of the best now in use. The bows are well placed and the grapes hang near the soil. The position of the shoots, however, is not so favorable as it might be. Half-bows of this variety are also met in Alsace. In the vicinity of Wolzheim, but a single stem is used, cut down to two canes bent as shown in Fig. 14 *a*. The stakes used in training the vines must be at least six feet in length. The vines must be placed about five feet from one another, so as to permit the entrance of light and the circulation of air.

In the valley of the Main, near Würzburg, a method is practiced in which only two bows are formed. In the upper part of Baden, in Switzerland, and in Siebenbürgen, the old wood is more closely pruned and two bows are grown from a single arm, as illustrated in Fig. 14 *b*. The other arm is pruned down to two or four buds and produces the bows of the following season. This, therefore, constitutes an "alternate renewal system." The bows, on account of the peculiar method of tying, can produce only short shoots. The system cannot be used for producing a fine quality of fruit.

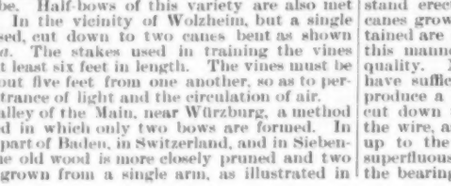



FIG. 16.—TRAINING THE STEM WITH ARMS AND BOWS.

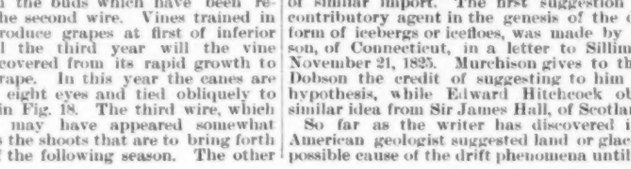



FIG. 17.—BUCK PRUNING.

It may not be uninteresting to give here a brief description of the methods practiced in La Champagne. The vines in this fertile province are set so closely together that sometimes 60,000 vines may be counted upon a single hectare (2·47 acres). The vines are kept well down, and are always supported by stakes, as indicated in Fig. 15. In February the old wood is partly buried in the soil, and the longest spur cut down to three eyes. The other spurs are cut entirely away. After pruning in February, the soil is cultivated in March to a depth of eight inches. At the same time each plant is uncovered, and the two-year-old wood so embedded in the soil that only a few spurs emerge. Such a system naturally produces a mass of superficial roots. The grapes hang very near the soil, and, being rich in sugar, are best adapted to the making of champagne.

A system not infrequently employed in Jura, France, is illustrated in Fig. 16. The stem, as seen in the engraving, is trained obliquely. In the center another arm is trained, which during the course of time lengthens and becomes stouter. The Jura growers sometimes use two supporting stakes, one for the unbent canes and the other for the bows. As illustrated in Fig. 16, however, a single inclined stake may be employed, which serves to support both canes and bow. The green shoots of the bow are allowed to grow freely and the grapes are but little shaded. In the following year the bow is grown on the other arm. If the canes on the bows have not developed sufficiently, the bow is grown at some portion of the arm where strong wood has been produced. The bow is then tied to the stem. The shoots growing from eyes on the stem are then tied to the stake perpendicularly. By this means strong canes are obtained, which can be used to form the bows of the next season.

FIG. 18.—GUYOT'S SYSTEM.

A singular method of training the arms is found in the "Würzburg System." According to this system, three arms are trained on a single stem, as shown in Fig. 17 *b*. The arms with their ends form a triangle. Each arm is supported by a stake six feet long, to which stake the bearing canes of the following season are tied, the ends of the bows being always tied to the stake of an adjacent arm.

A system productive of good hardy vines is the Guyot system, shown in Fig. 18. The trenches in which the vines are planted should be eight feet distant from one another and should be well fertilized. In the second or third year strong canes are produced shoots grow freely, and are afterward pruned down. Spurs should always be provided for a renewal of the arm. It is said that vines trained according to this system and grown in well fertilized and cultivated soil will yield in a favorable southern climate 1600 gallons to the acre without exhausting the strength of the vines.—Der Stein der Weisen.

## GLACIAL GEOLOGY IN AMERICA.*

By HERMAN L. FAIRCHILD.

### INTRODUCTION.

THE life of this Association, with that of its predecessor, covers precisely the period since the glacial theory was introduced to American geologists. It seems highly appropriate, upon the occasion of this jubilee meeting of the Society, to review briefly the history and growth of glacial geology in America and to give credit to the men who were pioneers or who have been most influential in the development of this young and vigorous branch of earth-study.

In the limits of this paper it is impossible to call the roll of all the investigators in American glaciology, and apology is here offered for many omissions and possible errors. †

### THE GLACIAL THEORY.

Announcement.—The "drift" of the northern United States and Canada was not neglected by the self-taught geologists of the early part of this century. Frequent references occur in the writings of those years to the striæ and polished rocks, the stony clay, the deposits of sand and gravel, and particularly to the conspicuous erratics and perched bowlders. These phenomena were commonly attributed to the agency of violent floods, and were called "diluvial." They were, however, so unlike any products of observable aqueous action that the conditions of their formation were a subject of imagination rather than of scientific inquiry. But this conception of water as the chief or only agent concerned in the production of the drift and striæ gained such general assent and so bound the minds of the older American geologists that the glacial theory was not given at first even a respectful hearing, and it was not accepted until long after a majority of foreign geologists had adopted it for western Europe and the British Islands, not, indeed, until a new generation of workers had possession of the field. The story of the introduction, discussion, and final acceptance of the glacial theory in America is an entertaining and instructive chapter in the history of science.

The reports of the early State Geological Surveys, the transactions of learned societies, and the volumes of Silliman's Journal down to about 1850 contain frequent references to "diluvial drift," "diluvial scratches," "tremendous currents of water" and terms of similar import. The first suggestion of ice as a contributory agent in the genesis of the drift, in the form of icebergs or icefloes, was made by Peter Dobson, of Connecticut, in a letter to Silliman,* dated November 21, 1825. Murchison gives to this letter of Dobson the credit of suggesting to him the iceberg hypothesis, while Edward Hitchcock obtained his similar idea from Sir James Hall, of Scotland.

So far as the writer has discovered in print, no American geologist suggested land or glacier ice as a possible cause of the drift phenomena until 1837, when T. A. Conrad asserted his belief in such agency in the following words:

"Whence then this immense body of ice which has scattered bowlders over so vast a tract of country, appearing, too, at an epoch subsequent to the extinction of the mastodon and other mammalia, which evidently lived in this region and enjoyed equatorial climate anterior to the icy period? Nothing can reconcile this apparent contradiction but the admission of a fall of temperature far below that which prevails in our day, freezing the enormous lakes of that period and converting them into immense glaciers, which probably continued undiminished during a long series of years."

We cannot, however, regard Conrad's suggestion as a fair presentation of the glacial theory. It was made only incidentally, as an argument for his hypothesis of epochs of cold climate, and without any attempt to give a full statement or to marshal the facts as bearing upon the genesis of the drift. It is significant, however, as indicating, by the casual way in which he introduces the argument, that the conception of great bodies of land ice might not have been, even at that time, an entirely new idea to American geologists. The work which then had been prosecuted for some years upon the Alpine glaciers was probably not entirely unnoticed by Americans.

The American geologist who first gave a favorable reception to the glacial theory of Agassiz, as far as printed records show, was Edward Hitchcock. In his address as retiring president at the second annual meeting of the Association of American Geologists and Naturalists, held at Philadelphia, April, 1841, he described the characters of the drift and the various phenomena which we now call glacial with great accuracy and appreciation. After discussing several hypotheses of the drift, he writes as follows:

"But the recent work of Agassiz, entitled 'Etudes sur les Glaciers,' gives a new aspect to the subject. . . . . Henceforth, however, glacial action must form an important chapter in geology. While reading this work and the abstracts of some papers by Agassiz, Buckland, and Lyell, on the evidence of ancient glaciers in Scotland and England, I seemed to be acquiring a new geological sense; and I now look upon our smoothed and striated rocks, our accumulations of gravel, and the tout ensemble of diluvial phenomena with new eyes."

". . . . . I do not mention these difficulties (to which I might add more) as any strong evidence against this theory. For so remarkably does it solve most of the phenomena of diluvial action, that I am constrained to believe its fundamental principles to be founded in truth."

In the application of the hypothesis to American drift he stated his chief difficulties to be: (1) The general southerly direction of the striæ and drift transportation over New England and New York, instead of radiating from the highlands as in the Alps; (2) the lifting of the erratics from lower to higher levels, although for this work he regarded ice as more efficient than water; and (3) the localized drift masses which we now call "drumlins." At that time, with only Alpine glacier phenomena as the foundation of the theory, these were valid and forcible objections. Indeed, his presentation of the argument for and against glacial agency showed excellent appreciation and grasp of the subject, and to-day can be read with profit. This is also true of his "postscript," discussing the glacier hypothesis and moraines in the introduction to his Geology of Massachusetts, 1841.

In these writings Prof. Hitchcock seemed to declare his adherence to the glacial hypothesis, as applied to

* Address before the Boston meeting American Association Advancement of Science, Section E.

† The writer hopes to insert in the record of Section E for the next meeting (1899) a notice of any important additions or corrections which are brought to his attention.

* It is not desirable to encumber these pages with a great number of bibliographic references. These can be found in chronologic order under authors' names in United States Geological Survey Bulletin No. 127—"Catalogue and Index of Contributions to North American Geology, 1732–1891," by N. H. Darton. (See "Glaciology," page 417 and "Pleistocene," page 736.) Bulletins Nos. 130 and 135 contain the bibliography from 1891 to the close of 1895.

America, with as little hesitation and qualification as would be expected of a careful man of science in espousing a new theory that antagonized the prevailing belief and prejudice of his fellow workers. It is evident from subsequent records that his utterances were accepted at the time as committing him to the acceptance of the theory of Agassiz. But, unfortunately for truth and for American geology, the circumstances and scientific forces of that time did not allow him to stand upon the advanced ground he had taken. He was criticised by Murchison, to whom he was attached, and evidently found no support among his confrères at home. Instead of following Buckland in support of the glacial theory, he went over to the side of Murchison and Lyell, and the next year at the Boston meeting his elaborate paper on the drift favored the iceberg hypothesis. In 1843 he is quoted in the following words:

"Prof. Hitchcock remarked that so disastrous had been his experience in respect to the glacial theory of Agassiz that he was almost afraid to say anything more on the subject. . . . . He had been supposed to be an advocate for the unmodified glacial theory. But if he could trust his own consciousness, he had never been a believer in it. . . . . By this term (glacio-aqueous) he meant to say that the phenomena of drift were the result of joint action of ice and water, without saying which of these agents had exerted the greatest influence. But whether that glacio-aqueous action had been the result of the enormous accumulation of glaciers, according to Agassiz, or from floating icebergs, . . . . . according to Lyell and Murchison, or of the upheaval of the Arctic Ocean whereby its aqueo-glacial contents were precipitated southward, according to De la Beche, he had not then made up his mind nor has he yet made it up."

Prof. Hitchcock's attempt to find some compromise between the glacial and iceberg theories of the drift was a failure. He came very near to being a glacialist. If he had followed his own perception of the truth, he would have been the leader in a great forward movement in geological science, which, by his defection at the critical moment, was suppressed for twenty years.

Discussion.—The printed accounts of the annual meetings of the Association of American Geologists and Naturalists give evidence of a lively interest in the subject of the drift, but there seems to have been no champion of the discredited glacial hypothesis; or if so, he was not thought worthy of record. There was much difference of opinion as to the agencies of the drift, but all were hostile to the new theory. The brothers Rogers, with Emmons, Jackson, Nicollet, Redfield, Couthuoy and others, lost no opportunity of upholding some form of the diluvial hypothesis, and for ten years no American geologist ventured openly to adopt and proclaim the theory of Agassiz. Doubtless there were various reasons for this unreceptive attitude, some of which we can discover. Lyell came to America in 1841, and in 1842 he attended the third meeting of the Geologists, held at Boston, and brought the reinforcement of his great reputation to those who favored the hypothesis of submergence and icebergs, of which he and Murchison were the great apostles. The supporters of this theory probably did not clearly understand the genesis of icebergs and did not realize that their hypothesis simply pushed the glacier area some distance northward. The scientific objections to the glacial origin of the drift were to them conclusive. They were unable to apply to the broad plateaus of northeastern America the work of local or Alpine glaciers. How could ice flow up hill? The glaciers of the Alps all moved down the slopes. How could an ice mass move over even comparatively level tracts? Indeed, Dana did not answer this difficulty until the 1879 edition of his Manual. The prevailing southerly direction of the drift movement, with only minor deflections by mountain masses or great valleys, did not harmonize with conceptions derived from written descriptions of the glaciers of the Alps, and they were not prepared to grasp Agassiz's idea of a great circumpolar ice sheet. The very large proportion of water-worn or water-laid materials in the drift certainly favored aqueous agency.

But there were other antagonistic forces which were not of a scientific character. Agassiz was a comparatively young man and quite unknown in geology except for his studies of glaciers. How could his opinion weigh against those of the giants in geology? Another power, which will scarcely appear in the scientific writings of the time, but which was a great conservative force, was theological opinion. All hypotheses invoking water as the drift agency might be harmonized with belief in the Noachian deluge, but the Bible gave no countenance to an ice deluge. The "diluvium" was an ever present evidence of the truth of the deluge. To explain it away was little better than heresy. In these days of liberty of thought it is not possible for us to realize the repressive power of religious opinion in Puritan New England. Furthermore, the diluvial hypotheses were unduly deductive, and like all opinions not based on observational or inductive evidence did not readily yield to the arguments derived from facts. The older geologists had made up their minds, and that settled it. They were also mostly committed in print to some form of the diluvial idea. Those early classics in American geology, the State reports of New York, Massachusetts, and New Hampshire, appeared during the years 1841–1844, and by generally referring the drift to aqueous origin helped to fix opinion along diluvial lines. Before leaving this subject it will be well to state briefly the nature of some of the theories of the drift.

Edward Hitchcock had written the Geology of Massachusetts before he became fully acquainted with the theory of Agassiz. He presents the several hypotheses for the drift, but rules out glaciers, retains the term "diluvium," and favors the idea of waves of translation from the Arctic region. He displays, however, the openness of mind and keen perception which led him virtually to adopt the glacial theory upon its first fair presentation, by distinctly saying that no theory proposed at that time was satisfactory to him. His "Postscript," describing glacial phenomena, at the beginning of the volume was an after-thought, dated 1841.

Lardner Vanuxem in his Geology of the Third New York District, 1842, referred briefly to the drift, compared the iceberg and glacial theories and gave preference to the latter in some modified form, suggesting the term "local ice" for "glaciers."

In the same year Ebenezer Emmons published the Geology of the Second New York District. He regarded the iceberg theory as fully established. The rock scorings and finer drift he thought were produced by broad shallow currents or rivers, at an earlier epoch, while during a later marine submergence the floating ice had transported the erratics and coarser drift. Glaciers were entirely ruled out.

W. W. Mather in the Geology of the First New York District, 1843, gave an exhaustive account of the drift. Regarding the glacial theory he had the objections noted by Hitchcock. He favored currents of water and floating ice, and thought that the greater currents were due to a relatively sudden collapse of the earth's crust, producing accelerated velocity of rotation, and hence quickened oceanic currents.

In the Geology of the Fourth New York District, 1843, James Hall held views similar to Emmons. He had not seen the writings of Agassiz, and probably very few American geologists had at that time, but he could not admit glacial agency, as there was no sufficiently elevated land-mass upon the north.

C. T. Jackson, in his Geology of New Hampshire, 1844, quoted M. de Luc against the glacial theory, even as applied to Europe, and regarded its application to America as absurd. He attributed the drift to Arctic waters and ice, they "having been hurled with great violence over the surface of the northern hemisphere."

In a review of Dr. Jackson's report, T. T. Bouvé wrote as follows:

"In view of all that is known of the movement of diluvium in this country, we cannot but regard the glacial theory as wholly inadequate to produce the results met with, and we think, with Dr. Jackson, that the grooves on the rocks, if produced by glaciers, should radiate from our principal mountain ranges and should be more abundant in their immediate vicinity, while they should be wanting in the level country and over our extended tablelands!"

The most ardent and extreme champion of De la Beche's hypothesis of catastrophic waves or debacles of water was Prof. H. D. Rogers. The following quotation from his presidential address before the fifth meeting of the Association of American Geologists, held at Washington, May, 1844, will give a sufficient idea of this hypothesis. After discussing the drift at great length and reviewing all the explanations that had been proposed, he gives the following as his own views:

"If we will conceive, then, a wide expanse of waters, less perhaps than one thousand feet in depth, dislodged from high northern or circumpolar basin, by a general lifting of that region of perhaps a hundred feet, and an equal subsidence of the country south, and imagine this whole mass converted, by earthquake pulsations of the breadth which such undulations have, into a series of stupendous and rapid-moving waves of translation, helped on by the still more rapid flexures of the floor over which they move, and then advert to the shattering power of the tremendous jar of the earthquake, we shall have an agent adequate in every way to produce the results we see, to float the northern ice from its moorings, to rip off, assisted with its aid, the outcrops of the hardest strata, to grind up and strew wide their fragments, to scour down the whole rocky floor, and, gathering energy with resistance, to sweep up the slopes and over the highest mountains."

To us at the present time it would seem as if the mere statement of this hypothesis should have been sufficient for its own refutation. Certainly it was so far-fetched, calling in an agency entirely outside the range of human observation and knowledge, and at the same time denying the competency of an observable agency which was at that time reproducing some of the most important drift phenomena, that it seems unscientific to the last degree. Yet, in 1849, three years after Agassiz had come to America and long after the detailed arguments for glacial agency had been fully and clearly set before American readers, Prof. Rogers wrote:

"V. The Diluvial Hypothesis, as modified by myself, assumes, not the submersion of the land, but a series of violent elevatory earthquake movements, in the Arctic regions, displacing the Arctic waters, with the ice which bound them, and sending these southward, across the northern districts of the continents."

As early as 1842 the facts concerning the geologic work of the Alpine glaciers and the arguments for the glacial theory had been placed before American readers by the republication in Silliman's Journal of an excellent article by Charles Maclaren. And in the next year an elaborate review in the same journal of James Forbes' noble book on glaciers left American geologists with no excuse for lack of general knowledge of the glacial theory and its reasonable claims.

Late in 1846 Louis Agassiz arrived in America. In 1847 he explored the White Mountains and found evidence of local glaciers. In 1848 he visited the great lakes and found abundant evidence of continental glaciation. In September of that year he attended the first meeting of this Society, at Philadelphia, and described the glacial phenomena about Lake Superior, showing the identity of the phenomena in America with those in Europe. To his personal testimony was added that of Arnold Guyot and Edmund Desor, who had been colaborers with him and had also brought their ample experience to bear upon the American field. The reception by the older geologists of this personal and expert evidence was evidently not of such a character as to encourage Agassiz in further presentation of the matter. In his book on Lake Superior, published 1850, he wrote in a somewhat sarcastic vein as follows:

"But such is the prejudice of many geologists that those keen faculties of distinction and generalization, that power of superior perception and discrimination which have led them to make such brilliant discoveries in geology in general, seem to abandon them at once as soon as they look at the erratics."

Agassiz did not present another glacial paper before the Association until 1870, his chief work in the meantime lying in the domain of zoology. However, from about 1850 the extreme diluvial notions were either abandoned or presented less aggressively.

At the second meeting of this Association, in Cambridge, 1849, there was the usual animated discussion of the drift, following papers by H. D. Rogers and Arnold Guyot. An extended paper by the latter described the glacial phenomena in the Alps, and stated that those of the White Mountains were similar. The diluvialists still opposed the glacier theory, even to the degree of questioning the Alpine observations of Guyot and Agassiz. James Hall evidently voiced the sentiments of the younger men when he said, as reported in the discussion:

"In this country there had been a tendency to oppose the glacial theory because it had been applied for the explanation of diluvial phenomena. We ought to be ashamed in this country, he said, to speak with confidence, after so little research, when there had been so much abroad."

From this time there are fewer references to the origin of the drift. A new generation of geologists was taking the place of the older men, and they were freer to accept the new ideas while not aggressively attacking the prevailing ones. The writings of the younger men frequently refer to glacial agency as an admitted fact. Among the contributions to glacial geology in those earliest years of the science but very few can be noticed. In 1850 C. B. Adams, at the New Haven meeting of the Association, read a paper on changes of level in North America, in which, adopting the hypothesis of Lyell, he suggested the elevation of northern land as sufficient cause of the ice sheet; also of submergence at the close of the glacial period to account for the undisputed marine deposits. This hypothesis was elaborated by Dana in his presidential address of 1855, and placed upon a working basis by three time divisions: (1) Glacial epoch, with northern elevation of land; (2) Laurentian epoch of depression; and (3) Terrace epoch, of moderate re-elevation to present altitude. From this time Dana was the leader of the glacial forces and the chief exponent of the theory.

In 1857 Edward Hitchcock published in the Smithsonian Contributions his extended and valuable paper on Surface Geology, treating chiefly of the Connecticut Valley. He distinguished local glacial striæ from general drift striæ, and recognized moraines and other effects of local glaciers. In 1859 C. H. Hitchcock made the same discrimination for New England in general. The Geology of Vermont, published in 1861, while describing phenomena of local glaciers, attributed the common drift to icebergs. In 1863 the report of progress of the Geological Survey of Canada from its beginning to that date contained a chapter on surface geology, written by Robert Bell, which attributed the drift phenomena to ice and fully accepted the glacial theory, even recognizing moraines in the Ottawa Valley.

Acceptance.—It will be seen that the acceptance, in America, of the glacial theory was by slow degrees. It involved the displacement of preconceived deductive hypotheses, and was opposed by the modified and not unreasonable theory of submergence and floating ice, held by Murchison and Lyell, which still has some qualified support. During the decade from 1850 to 1860 there was comparatively less discussion of the drift problem. Geologists were readjusting their ideas and taking new bearings. Then followed the years of the war of the Rebellion, when the thought of Americans was turned away from abstract science and even the meetings of this society were suspended. However, in 1862, the glacial theory received two notable reinforcements. One was, in England, its public adoption by Ramsay and his abandonment of the iceberg theory; the other, in America, the publication of the first edition of Dana's Manual of Geology. In this epoch-making book in geological science the whole problem of the drift was clearly presented. The arguments for and against both the iceberg and glacial theories were stated with a logical conclusion in favor of the latter, allowing the work of icebergs along the continental borders and across deep channels. An unbiased reader could judge for himself of the merits of the two theories, but could scarcely fail to accept the conclusion of the author. The glacial epoch as a division of Post-Tertiary time was given its place in the geological time series; and the various elements of the glacial problem were placed before student and worker so as to be available as a basis for investigation. The foundation was laid for the construction of glacial geology, but the time was not propitious for its completion.

Following the close of the war, interest was renewed in glaciology, and two papers by Charles Whittlesey, in 1866 and 1867, are worthy of note. In the latter year a masterly paper by Edward Hungerford, before this Association, discussed the physical conditions and climate of the glacial period. He did not agree with Agassiz's extreme views of great southern extension of a polar ice-cap; and his moderate conclusions are in general accepted to-day.

At this opportune time, 1867, when the greatly stimulated thought of the people was turned into peaceful ways, the revised edition of Dana's Manual carried the glacial theory into every college of the land as the evolutionary product of the discussion upon the drift during the fourth of a century. However, the theory still found some opposition, and as late as 1871 Dana said that American geologists were divided on the iceberg and glacial theories, and he deemed it necessary to give further proofs against the former.

When shall we say that glacial geology had its beginning in America? The discussion of the theory began in 1841 with the address of Edward Hitchcock. The acceptance of the theory by any number of Americans could not have been earlier than the personal advocacy by Agassiz and Guyot in 1848 to 1850. In some qualified form the theory was doubtless adopted earlier by a few independent thinkers, as Conrad and Vanuxem. The general acceptance of the theory and the making of it a basis for systematic work and investigation was probably not before 1867.

The periods in the history of drift-study in America may be stated as follows:

Undisputed reign of diluvial hypothesis—to 1841.
Discussion of the glacial hypothesis—1841 to 1848
Gradual adoption of the glacial theory—1849 to 1866.
Development of glacial geology—1867 to date.

### THE ICE BODY.

Centers of Dispersion.—The early views of the unity and simplicity of the ice-cap, following Agassiz's extravagant hypothesis of hemispheres of ice, did not

long endure the test of advancing knowledge. The direction of striæ and the trend of peripheral moraines were soon recognized as indicating complexity of growth and of movement. In 1871 Dana argued for multiple centers of radial movement, and he referred the New England glacier to a source between the St. Lawrence and Hudson Bay. In 1879 he said there had been no ice-cap enveloping the whole polar region, and recognized also that an inclination of the land surface was not necessary for the movement of the ice-body. In 1880 W. J. McGee expressed the view that the polar regions were never more extensively glaciated than at the present time. Similar views were expressed by H. Carvill Lewis in 1886, who designated two centers of ice accumulation and radiation, on the east and west sides of Hudson Bay, and in 1889 by Robert Bell, the Nestor of Canadian glacialists.

Dr. G. M. Dawson in 1888 recognized a separate confluent ice mass in British Columbia between the Coast and Rocky Mountain ranges, and in 1890 he gave names to two ice bodies, Cordilleran for the one in British Columbia, and Laurentian for the eastern one, which he regarded as surrounding Hudson Bay. In 1895 J. B. Tyrrell restricted the name Laurentian (Laurentide) to the mass east of Hudson Bay, and gave the name Keewatin to the body west of Hudson Bay. These three centers ("glacial radiants" of Chaypole) were adopted by Prof. Chamberlin in his chapter on North American glaciology in the latest edition of Geikie's "The Great Ice Age." Dr. Dawson thinks the Keewatin and the Laurentian (Labradorian) centers should be regarded as constituting the "Laurentide group" as distinguished from the far separated Cordilleran mass.

Migration of Maxima.—The first definite suggestion of lack of contemporaneity in the growth and culmination of the glacial centers was made by Robert Chalmers in 1890. From study of till sheets, bowlder trains, etc., in the area of contention between adjacent ice centers, Dr. Dawson, in 1895, thought there had been a migration of glaciation from the Cordilleran to the Laurentian plateaus; and in 1896 Mr. Tyrrell made a further refinement by claiming that the Keewatin glacier center had its maximum later than the Cordilleran and earlier than the Labradorian; and that a fourth center over Greenland is in existence to-day. This theory of migration of maximum accumulation receives encouragement from the results of recent studies of the Alaskan and the Greenland ice sheets. While the Alaskan glaciers are believed to have been waning in later time, the Greenland ice cap has probably increased, at least on the east coast, during several centuries, or since the time of the Norse colonies.

Thickness.—In 1883 J. C. Smock published an article on the thickness of the ice over New England and the Middle States. Later observations have shown that the thickness of ice was sufficient to bury the highest mountain peaks within the ice field. Explorations of the Greenland ice cap have yielded data concerning the curving slope of the margin of the ice sheet which seem in the hands of Chamberlin and Upham to give a reliable basis for the comparison with ancient ice sheets. Mr. McGee estimated the thickness in northeastern Iowa as "500 feet a few miles from the margin, to an indefinite but not very much greater thickness in the interior of the ice body."

Direction of Flow.—Previous to 1879 W. J. McGee was able, by the study of topographic forms of the drift in northeastern Iowa, to determine the direction of ice flow without evidence from striæ. It is now recognized that drumlins and eskers are more trustworthy criteria of general direction of ice movement than the glacial striæ, which are more subject to the effect of local causes. Peripheral moraines are demonstration of the direction of flow at the margin of the ice sheet. By these several criteria it is now demonstrated that the ice movement followed the trend of the larger depressions and valleys. As early as 1863 Dana argued, from direction of striæ, for distinct glacial flow in the Connecticut and Hudson valleys. The very decided localization of movement in the basins of the Laurentian lakes was shown cartographically by Chamberlin in 1877.

Lobing of Margin.—This is closely related to the flow in the longitudinal valleys, and is produced by the concentration or massing of the marginal ice in such depressions. This was also shown by Chamberlin 1877 in his map of terminal moraines; those of the ice lobes filling the basins of the great lakes having a conspicuously looped, festooned, or crescentic character. Further study has emphasized the lobate form of the periphery of the ice sheet, at least during the recessional phase.

Driftless Areas.—The surprising and apparently inexplicable phenomenon of an area unaffected by ice action but wholly surrounded by glaciated territory was brought to notice by J. D. Whitney in 1862. Much doubt was felt regarding the nature and even the existence of this driftless area until the observations were fully confirmed by the detailed descriptions and illustrations in the elaborated paper by Chamberlin and Salisbury, published in 1886. The explanation is supposedly found to lie in the peculiar relation of ice movement through the basins, the ice being diverted from this area. Until recently this area was thought to be unique, but in 1891 Prof. Salisbury discovered another small driftless area in western Illinois.

Transportation of Drift.—The precise manner in which the ice carried its burden of rock debris has been in question. Mr. Upham has emphasized the amount of englacial drift. He argues that the differential flow of the ice induces ascending currents which lift the basal or subglacial drift into higher planes of the ice body. On the other hand, Prof. Chamberlin claims that the continental ice mass never held any considerable burden of englacial drift except near the base; and he finds support for his position in the essentially basal character of the debris in the Greenland glaciers. The existence of ascending currents in the ordinary flow of the ice sheet is not admitted by most students of glacial physics. The question is of some moment in relation to the manner of accumulation of localized masses of debris, such as drumlins, moraines, and eskers.

As a philosophical discussion of the character and work of a local ice body, the writings of W. J. McGee upon the glacial phenomena of northeastern Iowa deserve special mention.

(To be continued.)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